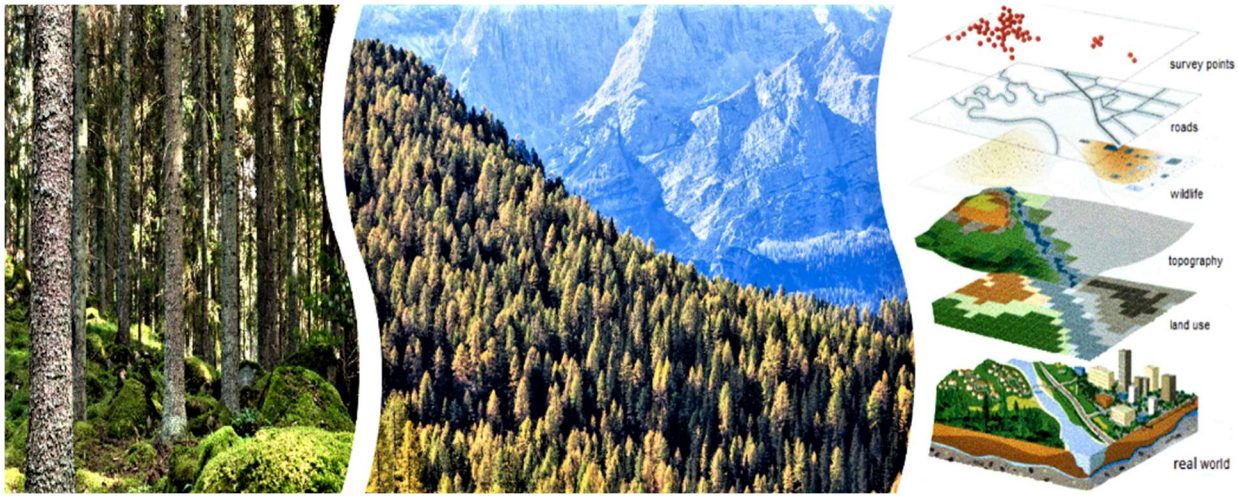

Tree Farm Licence 47
Management Plan #5
Timber Supply Information Package

Presented To: **TimberWest Forest Corp**

Dated: January 2024
Ecora File No.: 230170

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Version Control and Revision History

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B	2023 Dec 11	Miehm	MoF		Updated draft
C	2024 Jan 12	Miehm	TimberWest		For public review and consultation

Limitations of Report

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Acronyms and Abbreviations

AAC	Allowable Annual Cut
BC	British Columbia
BEC	Biogeoclimatic Ecosystem Classification
CFLB	Crown Forested Land Base
ECA	Equivalent Clearcut Area
EFZ	Enhanced Forestry Zone
FAIB	Forest Analysis Inventory Branch
GIS	Geographic Information Systems
Ha	Hectares
IRM	Integrated Resource Management
MoF	Ministry of Forests
MSYT	Managed Stand Yield Tables
NSYT	Natural Stand Yield Tables
OGMA	Old Growth Management Areas
PFLB	Productive Forest Land Base
RMZ	Resource Management Zone
RVQC	Recommended Visual Quality Class
SIA	Site Index Adjustment
SIBEC	Site Index Estimates by BEC Site Series
SRMZ	Special Resource Management Zone
THLB	Timber Harvesting Land Base
TIPSY	Table Interpolation Program for Stand Yields
TSA	Timber Supply Area
TSR	Timber Supply Review
UWR	Ungulate Winter Range
VAC	Visual Absorption Capacity
VDYP	Variable Density Yield Prediction Growth and Yield Model
VILUP	Vancouver Island Summary Land Use Plan

VQO	Visual Quality Objectives
VRI	Vegetation Resources Inventory
WHA	Wildlife Habitat Area

1. Introduction

Tree Farm Licence (TFL) 47 is an area-based tenure on provincial crown land that grants the licence holder (TimberWest Forest Corp.) the right to harvest timber and manage the forest and other resources extant within the tenure boundaries. Section 8 of the Forest Act requires that the Chief Forest (of BC) set an allowable annual cut (AAC) level at intervals of not less than ten years.

TimberWest is in the unprecedented position of requiring an AAC determination for only a part of their TFL area. The previous AAC determination for the entire TFL was made on February 4, 2014. On January 28, 2016, the Great Bear Rainforest Order (GBRO) was enacted. Part 10 of that order set the AAC for the GBR portion of the TFL to 388,500 m^3/year. As a result, a new AAC determination for this area will not be required until 2026. However, the areas outside the GBRO - Block 12 (Quadra Island) and Block 17 (Bonanza Lake) – require an AAC determination in 2024.

Despite this, TimberWest will prepare an MP for the entire TFL. Forest estate modelling will be conducted separately and in combination for the GBRO and non-GBRO parts of the TFL. These model results will inform several different planning processes, so it will be essential to be able to conduct analyses and draw conclusions for the entire TFL. The objective will be to develop the best management strategy for the TFL as a whole while providing the Chief Forester with the information needed to set an AAC for the non-GBRO areas.

The timber supply review and AAC determination is a multistep process that involves:

1) preparation of a draft Information Package that describes known information and current management practices;
2) completion of a timber supply analysis based on the information presented in the Information Package;
3) preparation of a Timber Supply Analysis Report documenting the results of the timber supply analysis;
4) submission to the Chief Forester of technical information, First Nations referral, and public review information; and
5) release of a rationale that describes the decision maker's AAC determination.

This document – the Information Package – addresses item #1 in the process steps listed above. It summarizes the inputs and assumptions made in preparing the timber supply analysis data set and model for the non-GBRO parts of TFL 47. Included are inventory and land base summaries, growth and yield information and management assumptions for timber and non-timber resources related to timber supply.

The Information Package allows the reader to consider the inputs and assumptions to be used in the timber supply analysis. These include:

- Current land base information, including documentation and sources information;
- Descriptions of current management practices and higher-level plans (HLP) in force;
- Legal objectives established under the Forest and Range Practices Act (FRPA) and the Land Act (i.e., VQOs, WHAs, UWR)
- Legal obligations arising from the GBRO
- Classification of the land base according to each hectare's contribution to management (harvest, resource management for wildlife, etc.);

- Land productivity estimates and prediction of stand growth and timber yield;
- Silviculture and harvesting regimes;
- Action taken to model multi-resource requirements; and
- Timber supply scenarios and sensitivity analyses to be evaluated.

This Information Package describes data and identifies management issues on TFL 47 that are relevant in determining a sustainable harvest level and in accordance with the guidelines set out in the document "*Provincial Guide for the Preparation of Information Packages and Analysis Reports for Area-based Tenures*". In addition to describing the scope and broad objectives of the timber supply analysis, this report will serve as a communication instrument in dealing with people and organizations interested in the project but not involved at a technical level. Upon acceptance by the MoF Timber Supply Analyst, the assumptions and methodology provided in the Information Package will be used to prepare and submit a timber supply analysis to the MoF.

2. Overview of the Area

TFL 47 comprises nine blocks on northern Vancouver Island near Port McNeill, parts of the coastal mainland and islands in the Johnstone Strait. The total TFL area is 123,943 hectares. The productive area of the TFL is 111,354 hectares. Figure 2.1 shows the location of the TFL and its component Blocks.

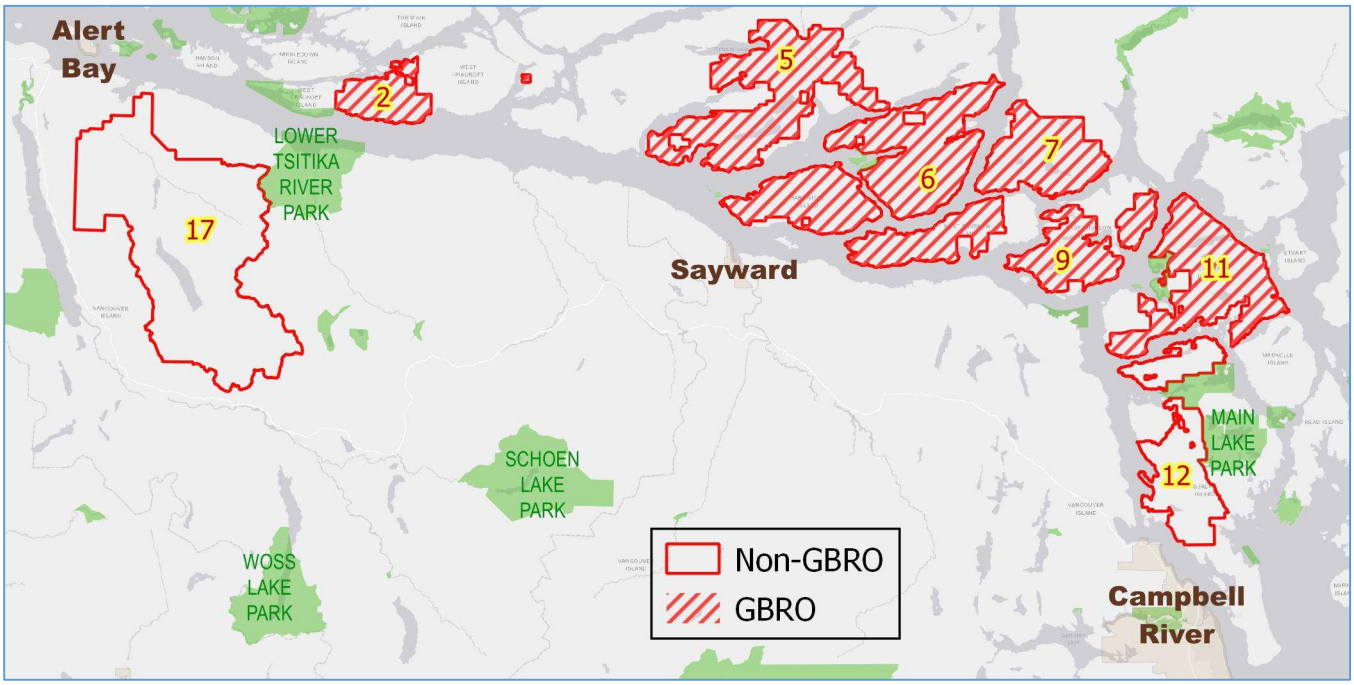


Figure 2.1 TFL 47 Location

TFL Blocks 2 through 11 fall within the GBRO. Block 12 (Quadra Island) and Block 17 (Bonanza Lake) are not covered by the GBRO and will have a new AAC set next year. Figure 2.2 shows a larger-scale view of these two blocks.

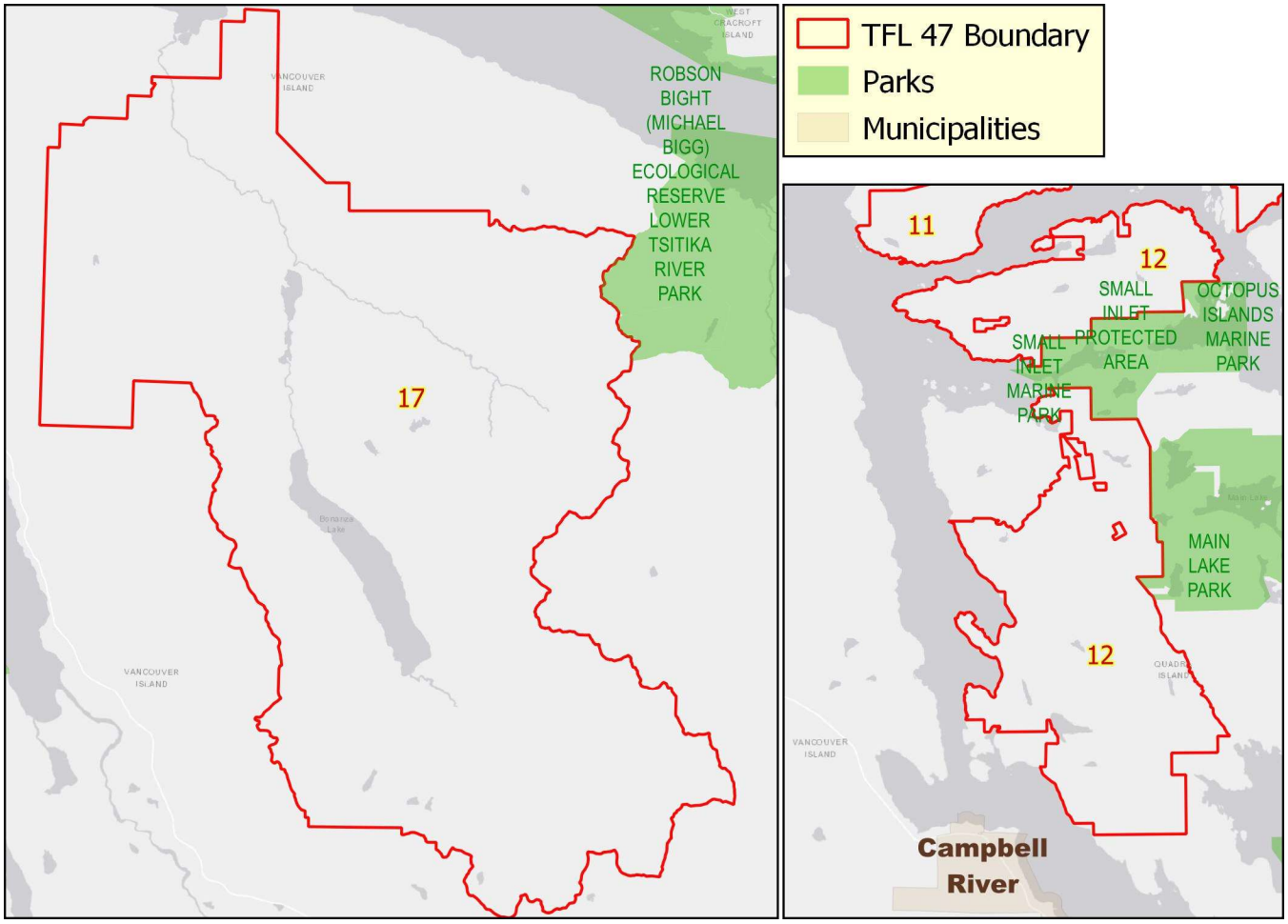


Figure 2.2 TFL 47 Block 17 (Bonanza Lake) and Block 12 (Quadra Island)

Block 17 lies south of Beaver Cove, north of the Island Highway and east of Nimpkish Lake. The total area of this block is 37,797 hectares, and the productive area is 32,861 hectares. Other nearby communities are Port McNeill, Alert Bay and Woss. The majority of the area lies within the Coastal Western Hemlock (CWH) biogeoclimatic (BGC) zone, with small portions in the Mountain Hemlock (MH) zone.

Block 12 (two separate blocks, actually) is on Quadra Island. It has a total area of 10,846 hectares and a productive area of 9,139 hectares. Nearby communities are Herriot Bay and Campbell River. The area falls entirely within the CWH BGC zone.

The GBRO area extends from Sonora Island in the east to West Cracroft Island in the west. It includes islands in the Johnstone Strait and portions of the adjacent mainland. It includes TFL Blocks 2 through 11 (West Cracroft, Port Harvey, Boughey Bay, Port Neville, Wellbore Channel, Deer Lake, West Thurlow, Simmons Lake, Hemming Bay and Sonora Island), which are characterized by coastline with mountainous terrain, which is not exceptionally rugged or steep. Most of the area lies within the CWH BGC zone, with small portions in the MH zone.

Figure 2.3 shows the biogeoclimatic variant distribution of TFL 47.

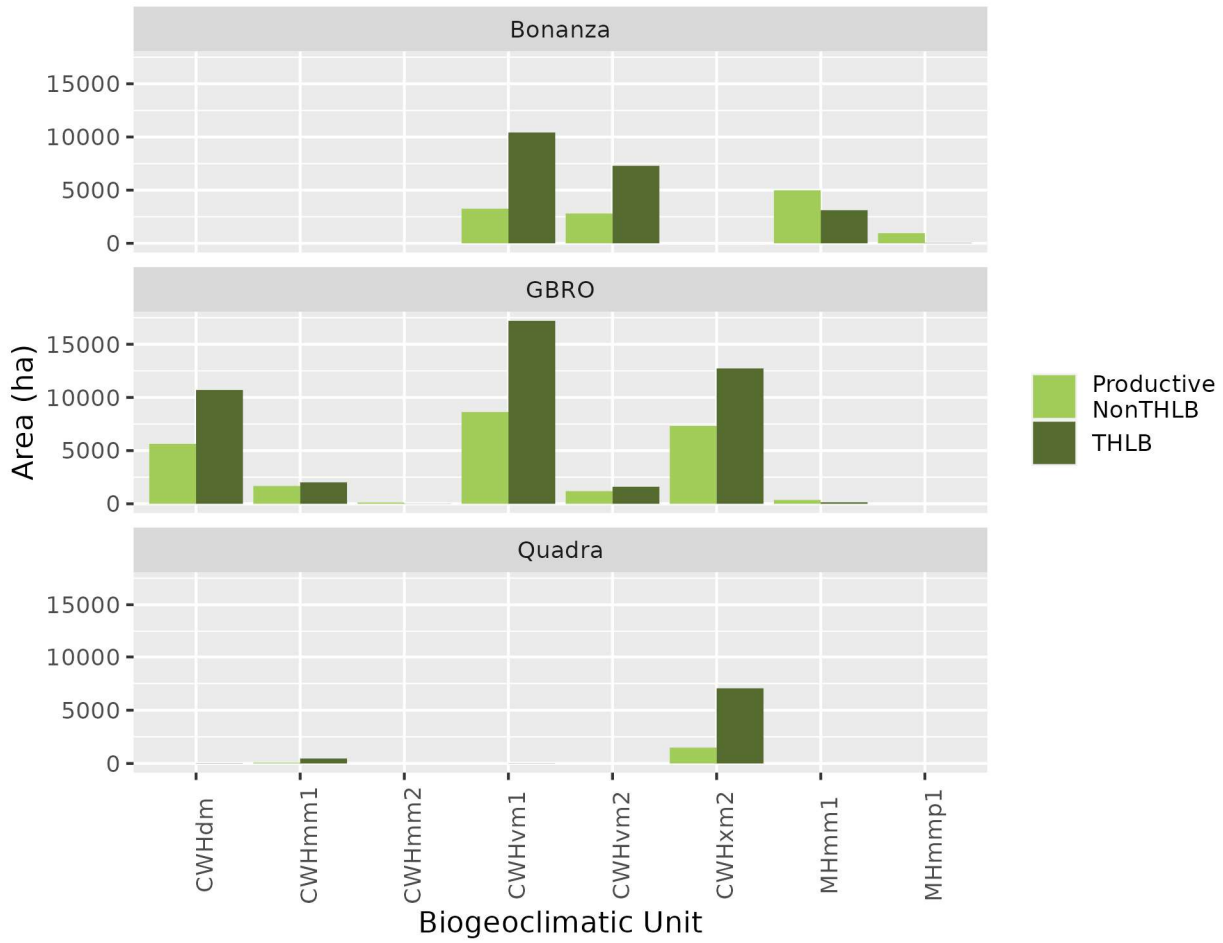


Figure 2.3 Forest Land Biogeoclimatic Distribution

Figure 2.4 shows the elevation distribution of the TFL. Most of Quadra Island (88%) and Johnstone Strait (85%) are below 400 metres in elevation. Only 3% of the Bonanza Lake falls below 200 metres. Most (95%) falls between 200 and 1400 metres in elevation.

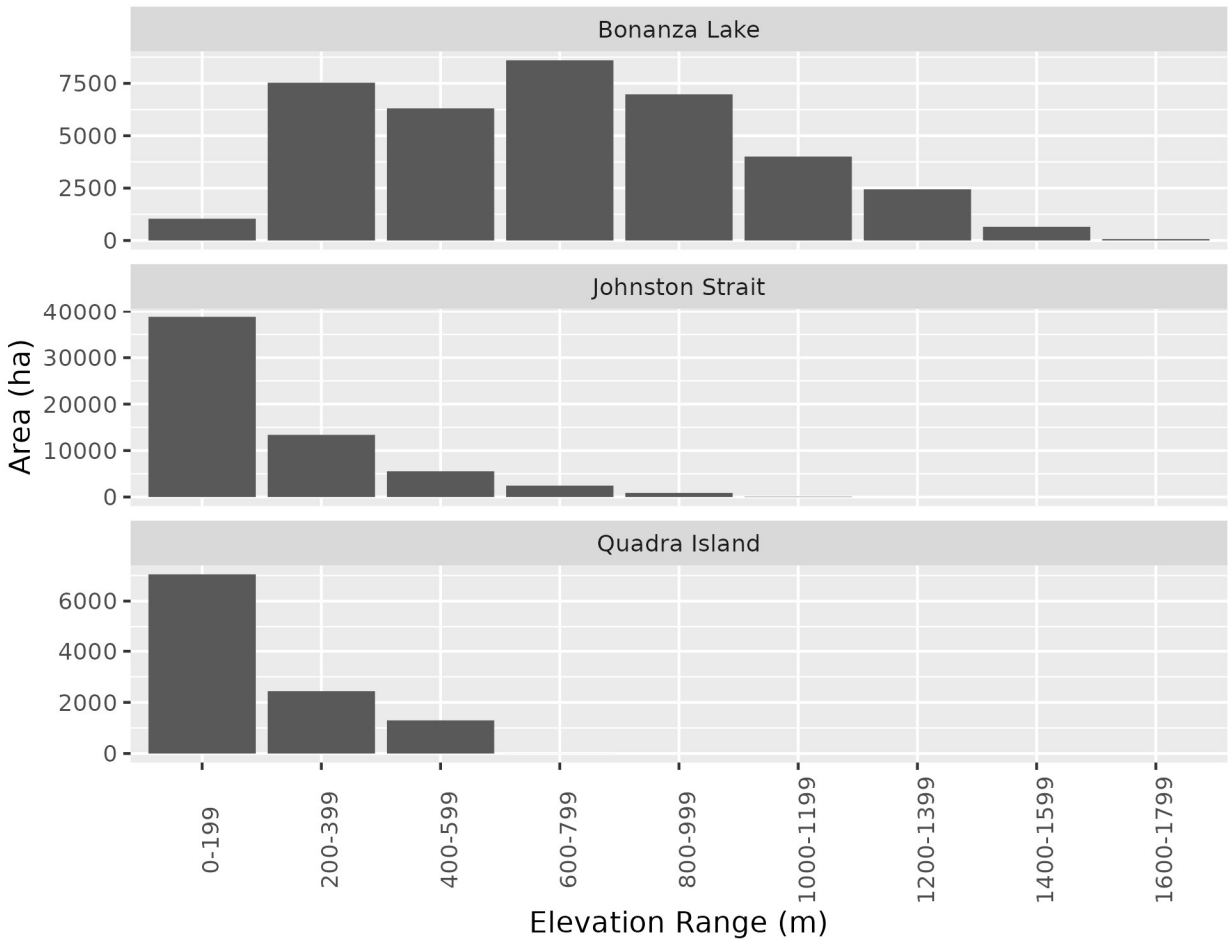


Figure 2.4 Elevation Distribution

The boundary of, and allowable annual cut assigned to, TFL 47 has changed considerably over the past 30 years. Most recently (February 2014), the AAC was set at 630,000 m^3/year. A partition was established for the area that, at the time, fell under the South Central Coast Order (SCCO). Harvesting was limited to 365,000 cubic metres annually. This harvest level included an 8000 m^3/year reduction for Boat Bay, Forward Harbour, the Thurston Bay extension and Hanson Island. This reduction – to account for *Central Coast Designated Area No. 2* - was made in error,

In August 2003, the AAC for the parts of TFL 47 that remain within its boundaries until the present day was set at 772,000 m^3/year. This harvest level included 492,000 m^3/year[1] attributable to Johnstone Strait and 180,000 m^3/year to Bonanza Lake[2]. These separate figures arise because TimberWest compiled independent harvest-level forecasts for these two management units. The Chief Forester took issue with this approach, stating that the Forest Act requires that the AAC determination be made for the TFL as a whole.

[1] This reflects an 8000 m^3/year reduction to reflect the prohibition on harvesting (*per* the *Central Coast Designated Area Regulation*) on Hanson Island.
[2] The determined AAC was actually much larger (780,000 m^3/year), since it included the Moresby MU that was being managed at the time by Teal Cedar Products Ltd.

In December 1996, the AAC for the entire TFL at that time was set at 865,000 m^3/year. Five partitions were set for the component Management Units. Two of those units remain in TFL 47 – Johnstone Strait (425,000 m^3/year) and Bonanza Lake (200,000 m^3/year).

TFL 47 resulted from the amalgamation of TFL 2 and TFL 12 in 1985. The AAC then was 1,090,000 m^3/year, albeit on a much larger land base (226,869 hectares).

The following First Nations have territorial or other interests that overlap TFL 47:

- 'Namgis First Nation
- Homalco First Nation
- K'ómoks First Nation
- Klahoose First Nation
- We Wai Kai Nation
- Wei Wai Kum First Nation
- Tlowitsis Nation
- Da'naxda'xw/Awaetlala First Nation
- Kwakiutl First Nation
- Kwiakah First Nation
- Mamalilikulla First Nation
- Tla'amin Nation

Not all of the First Nations on this list have concerns related to the portion of the TFL that is the subject of the pending AAC determination (Block 12 and Block 17).

3. Current Practice

TFL 47 is managed for timber production using a system of clearcutting with reserves. Harvesting is prohibited on parts of the forest land base where the restriction is necessary to meet other management obligations (e.g., wildlife habitat or water quality). Where harvesting is permitted, some standing timber is left as wildlife tree retention (WTR). Furthermore, harvesting may be further limited in some stands if the primary management objective is something other than timber production.

Higher-level plans (HLPs) document land use and forest resource management objectives that were set during regional strategic planning exercises. These include objectives established for the general public, First Nations, government agencies, and commercial interests. Resource management objectives established as HLPs are legally enforceable and provide direction affecting daily forestry operations.

3.1 Quadra Island and Bonanza Lake

Both Quadra Island and Bonanza Lake are subject to the Vancouver Island Summary Land Use Plan (VILUP). The VILUP process started in 1995 and culminated in the release of the plan document in 2000. The objectives of this plan are to:

- establish protected areas;

- secure the forest land base – specifically the area available for commercial timber use, recreation and tourism, mining and other sustainable resource-based activities;
- provide regional biodiversity direction;
- support food production activities;
- recognize settlement lands;
- maintain energy and mining opportunities;
- address integrated coastal management; and
- promote community stability.

VILUP objectives have been accomplished, in part, by zoning forest land into six categories: protected areas, special management zones (SMZ), enhanced forestry zones (EFZ), general resource management zones and areas designated for agriculture and settlement. SRMZs were designated for managing timber, biodiversity, wildlife, visual, recreation, tourism, and aquaculture resources. A portion of Quadra Island within TFL 47 is a designated SMZ. The entire Bonanza block is an EFZ. EFZs were implemented to enable greater flexibility for harvest operations while meeting objectives for other non-timber resource values.

3.2 Great Bear Rainforest Order

The remainder of the TFL (i.e., Blocks 2 to 11) are subject to the GBRO. This HLP came into effect in January 2016, replacing the South Central Coast Order (SCCO) that had been in force when MP#4 was prepared. The GBRO mandates an ecosystem-based management approach within the Great Bear Rainforest area.

3.3 Forest Stewardship Plans

A Forest Stewardship Plan (FSP) is not an HLP, but it does outline how forest development activities will be conducted in the area described in the Plan. It makes legal commitments that are subject to government inspections for compliance and enforcement.

FSPs are written and approved for up to five or – if extended – up to 10 years. The FSP also identifies general areas where forest development, such as harvesting and road work, may occur over the term of the FSP. These areas are identified as forest development units (FDUs). There is no requirement to show the location of cut blocks and roads in an FSP – only the general areas where development may occur over the term of the FSP.

At the beginning of this MP process, TimberWest had three FSPs in place for TFL 47:

- Bonanza (submitted 06 February 2023)
- Quadra – Quinsam (submitted 23 September 2022)
- Johnstone Strait (submitted 16 September 2022)

The government can hold agreement-holders accountable for their forest management practices based on commitments made in the 'results' or 'strategies' documented in the FSP. It also provides a vehicle for agreement-holders to solicit and consider the public's and other stakeholders' expectations for their use of Crown land and resources.

3.4 Management Changes Since MP#4

There have not been many changes to forest management objectives or practices since MP#4 was approved. The only two of note relate to Marbled Murrelet and old-growth harvest deferrals.

3.4.1 Marbled Murrelet Habitat

The Province manages Marbled Murrelet (MAMU) nesting habitat on provincial Crown land to support viable species populations throughout its range. The intent is to increase certainty on the land base for resource development and improve the likelihood that suitable habitat is maintained in a patch size and configuration that constitutes functional habitat.

The Order for the Recovery of Marbled Murrelet (*Brachyramphus marmoratus*) was issued in December 2021 to implement these objectives. That order mandated targets for suitable habitat at the landscape unit portion and landscape unit aggregate spatial resolutions. Those targets – for TFL 47 are shown in Table 3.1

Table 3.1 Marbled Murrelet Habitat Objectives

Landscape Unit Aggregate	Landscape Unit Portion	Aggregate Suitable Habitat Target (ha)	Portion Suitable Habitat Target (ha)	Portion Minimum Threshold (ha)
Comox Valley	Quadra	12,355	30	30
Nimpkish	Bonanza	6,929	199	159

The Marbled Murrelet Order does not specify habitat targets for the part of TFL 47 subject to the GBRO.

3.4.2 Old Growth Deferral Areas

In 2019, the Government of British Columbia appointed an independent, two-person panel as part of an Old Growth Strategic Review to engage with stakeholders and make recommendations to improve forest management generally, and old growth management in particular. The submitted their report to the MoF in April 2020.

One of the recommendations of that report was:

> *6. Until a new strategy is implemented, defer development in old forests where ecosystems are at very high and near-term risk of irreversible biodiversity loss.*

To that end, the provincial government formed a Technical Advisory Panel (TAP) in June 2021 to provide maps, analysis, and detailed status of old-growth ecosystems in BC. The identified three categories of Priority Deferral Areas;

- Priority big-treed old growth
- Ancient forest
- Remnant old ecosystems

Some of these areas fall within TFL 47. Table 3.2 shows the area of the TAP-designated polygons that fall within TFL 47.

Table 3.2 TAP Old Growth Polygon Area

TFL Region	TAP Polygon Area (ha)
Bonanza Lake	692
GBRO	2499
Quadra Island	237

A sensitivity analysis will examine the impact of prohibiting harvesting in these areas.

4. Inventories

Table 4.1 lists the spatial datasets compiled into the spatial resultant for this analysis. The 'Source Date' column shows when the data was received from TimberWest or downloaded from DataBC.

Table 4.1 Spatial Data Sources for TFL 47

Layer Description	GIS Layer Name	Source	Source Date
TFL 47 Boundary	tfl47_bdy_1	TimberWest	2023-03-01
Archaeological Sites (Engineering)	arch_eng_1	TimberWest	2023-03-01
Archaeological Sites (Government)	arch_gov_1	TimberWest	2023-03-01
BMTA	bmta_1	TimberWest	2023-03-01
Bonanza CWHvm2 Old Growth	bon_cwh_og_1	TimberWest	2023-03-01
Important Fisheries Watersheds	fish_wrtshed_1	TimberWest	2023-05-01
Foreshore	foreshore_1	TimberWest	2023-03-01
GBRO High-Value Fish Habitat	gbro_fish_1	TimberWest	2023-03-01
GBRO Grizzly Habitat	gbro_grizzly_1	TimberWest	2023-03-01
Goshawk	goshawk_1	TimberWest	2023-03-01
Harvest Planned Blocks 2023	blocks_plan_2023_1	TimberWest	
Heli Yarding	heli_1	TimberWest	2023-03-01
Landscape Reserve Design	lrd_1	TimberWest	2023-03-01
Landscape Units	Landscape Units of British Columbia - Current	DataBC	2023-01-01
Operability	operability_1	TimberWest	2023-03-01
Recreation Areas (Govt)	BC Controlled Recreation Areas	DataBC	2023-01-01
Recreation Trails (Govt)	Recreation Sites and Trails BC District Boundaries	DataBC	2023-01-01
Recreation Sites (TimberWest)	rec_sites_1	TimberWest	2023-05-01
Red Blue Listed Species	red_blue_1	TimberWest	2023-03-01
Riparian RRZ	rip_rrz_1	TimberWest	2023-03-01
Sample Plots Polygons	sample_plots_poly_1	TimberWest	2023-03-01
Sample Plots Points	sample_plots_pt	TimberWest	2023-03-01
TEM	tem_1	TimberWest	2023-03-01
Temporary Old Growth Reserves	temp_og_1	TimberWest	2023-03-01
Terrain Stability	terrain_1	TimberWest	2023-05-01
Ungulate Winter Range	Ungulate Winter Range - Approved	DataBC	2023-01-01
Visual Landscape Inventory (TimberWest)	vli_1	TimberWest	2023-05-01
Visual Landscape Inventory (Govt)	Visual Landscape Inventory	DataBC	2023-01-01
Wildlife Habitat Area	Wildlife Habitat Areas - Approved	DataBC	2023-01-01
Wildlife Tree Patches	wtp_1	TimberWest	2023-03-01
VRI 2022	VRI - 2022 - Forest Vegetation Composite Layer 1 (L1)	DataBC	2021
Recreation Inventory	Recreational Features Inventory	DataBC	2023-05-01

Layer Description	GIS Layer Name	Source	Source Date
TimberWest Landcover Classification Roads	TimberWest_lc_roads_1	Ecora	2023-02-01
Karst (govt)	Recreation Karst Inventory	DataBC	2023-01-01
Vancouver Land Use Plan	smz_1	TimberWest	2023-06-01
Forest Road Network (TimberWest)	roads_buff_1	TimberWest	2023-06-01
Results Cutblocks	RESULTS - Openings svw	DataBC	2023-06-01
Consolidated Cutblocks	Harvested Areas of BC (Consolidated Cutblocks)	DataBC	2023-11-01
Inventory Granite Bay	tw_inv_granitebay_1	TimberWest	2023-11-01

In addition to the data sources listed in the table, TimberWest has acquired LiDAR data to support a forest inventory of their private and public forest land holdings. The LiDAR dataset was used to amend operability mapping and riparian buffers and is currently being used to identify old roads that have become reforested.

4.1 Forest Inventory

The TFL 47 Phase I inventory is based on photo-interpreted inventory attribute estimates using the current VRI procedures and was completed in March 2007 using 2006 1:15,000 aerial photos. The VRI Phase II project ground sampling was conducted in 2007, 2008 and 2010. NVAF sampling was also completed in 2010. An adjustment of the Phase I was completed in 2010 using VDYP7. The results of the adjustment are summarized here. The complete adjustment report can be found in Appendix C.

For the Phase II adjustment, the target population was stratified by age and species using two age groups (30-100 years vs. 101+ years) and two species groups (Hw+Hm, vs. all others). VDYP input attributes were adjusted first. The resulting 'ratio-of-means' (ROM) estimates are shown in Table 4.2

Table 4.2 VRI Phase II Adjustment Ratios – VDYP Input Attributes

Stratum	Area (ha)	Stems Per Ha (ROM)	Height (ROM)	Lorey Height (ROM)	Basal Area (ROM)	Age (ROM)
H ≤ 100yrs	40,643	2.320	0.969	0.987	1.286	1.201
Other ≤ 100yrs	17,295	1.664	0.910	1.078	1.161	1.488
H > 100yrs	17,063	1.996	0.989	1.004	1.328	1.272
Other > 100yrs	13,277	2.130	1.130	0.974	1.580	1.671
Total	88,278	2.137	0.987	1.004	1.312	1.392

VDYP is run using the adjusted input attributes to generate stand volumes for the sampled stands. The results are compared to the volumes compiled from the sample plots, and a ROM for the volumes is calculated. This is shown in Table 4.3.

Table 4.3 VRI Phase II Volume Adjustment Ratios

Stratum	Area (ha)	12.5 cm+ Volume (ROM)	17.5 cm+ Volume (ROM)
H ≤ 100yrs	40,643	0.965	0.953
Other ≤ 100yrs	17,295	1.029	1.007
H > 100yrs	17,063	1.114	1.111
Other > 100yrs	13,277	1.076	1.080
Total	88,278	1.027	1.021

These adjustment factors will be applied to the Phase I NSYT used for the base case scenario, and these Phase II curves will be used for a sensitivity analysis.

As a result of boundary changes, a small portion of Block 12 (Quadra Island) is not covered by the TFL 47 VRI. Older inventory data from TimberWest archives was used for this area.

For this analysis, VRI data was retrieved from DataBC. That data had been updated for growth and depletions up to December 31, 2022. The starting date for the timber supply analysis will be January 1, 2023.

4.2 Terrestrial Ecosystem Mapping

Terrestrial Ecosystem Mapping (TEM) for TFL 47 was completed in the early 1980s by T. Lewis Consulting and updated in 1995 by B.A. Blackwell and Associates.

4.3 Terrain Stability Mapping

TimberWest maintains a consolidated terrain stability database for operational planning purposes. The mapping for the Johnstone Strait portion of the TFL was completed in 1993 to a terrain survey intensity level (TSIL) ‘E’. Terrain stability mapping for the Bonanza Lake block was completed in the late 1970s and early 1980s. It was reviewed and updated to TSIL ‘E’ standards in 1993 in conjunction with the completion of a Management Working Plan for the TFL. Part of the Bonanza Lake block was completed to TSIL ‘C’ standards under two separate projects completed in 1998 and 2000.

4.4 Recreation Inventory

A recreation features inventory was completed for TFL Blocks 4 through 12 in 1999 to the Resource Inventory Committee (RIC) standards that were in place at the time. An earlier inventory (1993/94) covered the norther TFL Blocks. The attribute structure of this inventory was subsequently updated to match the newer (1998) RIC standard.

5. Division of the Area into Zones and Analysis Units

One of the first steps in a timber supply analysis project is dividing the area of interest into management zones and analysis units to facilitate efficient forest estate modelling.

5.1 Management Zones

Management zones identify areas where the primary management objective in not timber extraction. The delineation of management zones is guided by legally established objectives, such as those contained in the Vancouver Island Summary Land Use Plan(VILUP), GBRO and Government Action Regulation (GAR) orders, and by other forest management considerations.

Table 5.1 lists the management objectives that are to be achieved in the timber supply analysis while still allowing trees to be harvested. Management objectives for which harvesting is not permitted (e.g., riparian reserve zones) are not listed in Table 3 as they are incorporated into the analysis through the netdown process described in Section 2.6.

Table 5.1 Management Zones

Management Zone / Objectives	Purpose	TFL Zone
Scenic Areas	Areas identified as visually sensitive and established as scenic areas require varying limits on harvest rates.	All
Landscape-level biodiversity	The Non-Spatial Old Growth Order set targets for the proportion of the forest to be maintained in an old seral condition. The objectives are applied by landscape unit and biogeoclimatic variant.	Non-GBRO
Important Fisheries Watersheds	These areas are managed primarily for fish habitat and water quality. The rate of timber harvesting is limited to meet these objectives.	GBRO

5.2 Analysis Units

Analysis units (AU) are aggregates of forest stands for growth and yield modelling. This aggregation was not necessary for natural stands (established before 1975), but managed stand yield tables are based on AUs based on TFL zone, BGC variant and site series. Table 5.2 lists these units.

Table 5.2 Analysis Units

	AU Name	BGC Variants	Site Series
1	B_CWHvm1_01	CWHvm1	01
2	B_CWHvm1_02	CWHvm1	02, 03, 04
3	B_CWHvm1_05	CWHvm1	05, 07, 08
4	B_CWHvm2_01	CWHvm2	01
5	B_CWHvm2_02	CWHvm2	02, 03, 04
6	B_CWHvm2_05	CWHvm2	05, 07, 08
7	B_CWHvm2_06	CWHvm2	06
8	B_CWHvm2_09	CWHvm2	09, 10, 11
9	B_MHmm1_01	MHmm1	All
10	J_CWHvm2_01	CWHvm2, MHmm1, CWHmm2	All
11	J_CWHxm_01	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	01
12	J_CWHxm_03	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	02, 03
13	J_CWHxm_05	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	04, 05
14	J_CWHxm_06	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	06
15	J_CWHxm_07	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	07, 08
16	J_CWHxm_12	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	12, 14
17	Q_CWHxm_01	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	01
18	Q_CWHxm_03	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	02, 03
19	Q_CWHxm_05	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	04, 05
20	Q_CWHxm_06	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	06
21	Q_CWHxm_07	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	07, 08

6. Land Base Classification

In some cases, individual areas may have several classification attributes. For example, stands within riparian reserve boundaries might also be classified as non-commercial. These areas would have been classified based on this latter attribute prior to the riparian classification. Therefore, in most cases, the net reduction will be less than the total area in the classification. Table 6.1 shows the netdown process through which the timber harvesting land base has been determined for the TFL. The order of the entries in the table corresponds to the sequence in which the land base classifications were applied.

These tables show that the total area of TFL 47 is 123,943 hectares, the forested land base under TimberWest's management control is 111,353 hectares, and the THLB area is 72,815 hectares.

Most of the TFL area is Schedule B crown land. Two types of Schedule A land exist on the TFL

1) fee simple parcels in Blocks 3, 6, 7, 11 and 12

2) Timber Licences in Blocks 6 and 17

Only the Quadra Island and Bonanza Lake Blocks will have a new AAC determined as a result of this planning process. Table 6.2 shows the land base classification process for this area only.

Table 6.1 Land Base Netdown Summary – All of TFL 47

	Land Category	Area (ha)		Timber Volume (m^3)	
		Total	Removed	Total	Removed
	TFL 47	**123,943**		**38,236,666**	
1	Biodiversity, Mining, and Tourism Area	320	320	133,321	133,321
2	Non-Forest	6,608	6,601	115,572	115,572
3	NP Site Series	6,338	1,981	253,576	246,192
4	Roads	3,724	3,688	1,012,695	1,008,346
	Crown Forest Management Land Base	**111,353**		**36,733,235**	
5	Inoperable	12,393	9,037	2,696,631	2,480,386
6	Problem Forest Types	1,693	981	183,779	118,404
7	Low Site - Low Slope	305	125	15,054	5,860
8	Low Site - High Slope	2,542	541	161,515	40,034
9	Low Site - Alder	146	123	13,562	11,446
10	Low Volume Mature	8,820	3,190	959,695	511,323
11	Wildlife Tree Retention / Riparian	3,718	3,414	1,832,301	1,732,030
12	Recreation Inventory 100%	603	9	29,990	3,581
13	Recreation Trail	32	20	11,874	8,400
14	Recreation Reserve	8	7	6,614	5,856
15	Recreation Site	52	35	27,204	17,013
16	Archaeological - Engineering	118	81	64,700	44,526
17	Archaeological - Government	52	15	24,750	4,339
18	Riparian Reserve	8,482	4,557	3,276,103	2,256,842
19	Quadra Foreshore	128	78	45,709	37,884
20	High-Value Fish Habitat	597	361	330,110	201,528
21	Ungulate Winter Range	1,015	810	521,426	440,018
22	Wildlife Habitat Area	1,127	789	652,071	453,120
23	Goshawk Nesting Habitat	964	584	553,028	355,743
24	Grizzly Type 1 Habitat	920	239	422,254	128,043
25	Red-Listed Plant Communities	1,709	1,081	604,706	420,532
26	Karst (TimberWest)	122	100	36,828	27,376
27	Bonanza CWHvm1 OG	1,369	545	820,992	318,663
28	Landscape Reserve Design	23,130	9,905	10,301,137	4,706,959
29	Blue-Listed Plant Communities	2,534	55	1,150,021	20,846
30	Recreation Inventory (50%)	1,784	284	405,719	89,833
31	Terrain Class V (90%)	3,863	632	1,242,321	302,624
32	Terrain Class IV (20%)	11,368	940	4,542,158	385,024
	Timber Harvesting Land Base	**72,815**		**21,605,004**	

Table 6.2 Land Base Netdown Summary – Bonanza Lake and Quadra Island

	Netdown Factor	Total Area (ha)	Area Removed (ha)	Total Volume (m^3)	Volume Removed (m^3)
	TFL 47- Block 12 and 17	**48,644**		**13,637,621**	
1	Biodiversity, Mining, and Tourism Area				
2	Non-Forest	7,790	3,735	115,572	93,435
3	NP Site Series	327	1,455	253,576	152,993
4	Roads	176	1,455	1,012,695	415,045
	Analysis Forested Land Base	**42,000**		**12,976,148**	
5	Inoperable	7,790	5,232	2,681,253	1,007,686
6	Problem Forest Types	327	220	183,779	21,550
7	Low Site - Low Slope	176	64	15,054	3,169
8	Low Site - High Slope	1,390	255	161,515	21,981
9	Low Site - Alder	19	14	13,562	186
10	Low Volume Mature	7,213	2,289	959,695	336,082
11	Wildlife Tree Retention / Riparian	879	743	1,832,301	344,648
12	Recreation Inventory 100%	603	9	29,990	3,581
13	Recreation Trail	32	20	11,874	8,400
14	Recreation Reserve	8	7	6,614	5,856
15	Recreation Site				
16	Archaeological - Engineering	10	9	64,700	5,929
17	Archaeological - Government				
18	Riparian Reserve	3,839	1,742	3,276,103	846,715
19	Quadra Foreshore	128	78	45,709	37,884
20	High-Value Fish Habitat				
21	Ungulate Winter Range	1,015	810	521,426	440,018
22	Wildlife Habitat Area	359	194	652,071	116,086
23	Goshawk Nesting Habitat	201	163	553,028	135,690
24	Grizzly Type 1 Habitat				
25	Red-Listed Plant Communities				
26	Karst (TimberWest)	122	100	36,828	27,376
27	Bonanza CWHvm1 OG	1,369	547	820,992	318,675
28	Landscape Reserve Design				
29	Blue-Listed Plant Communities				
30	Recreation Inventory (50%)	1,784	285	405,719	89,837
31	Terrain Class V (90%)	2,499	535	1,242,321	259,061
32	Terrain Class IV (20%)	2,932	263	4,542,158	105,494
	Timber Harvesting Land Base	**28,422**		**8,840,243**	

6.1 Identifying the Forest Management Land Base

This Information Package includes a description of issues, information sources, assumptions, and criteria used to estimate the land base available for timber harvesting, including any relevant data processing or adjustments. Land is classified as ‘Productive’ or ‘Non-Productive’; the productive land base is then netted down to determine the Timber Harvesting Land Base (THLB).

6.1.1 Lands Not Managed By the Tenure Holder

Biodiversity, Mining and Tourism Areas (BMTA) were established by an Order in Council (OIC) in 2009. The ‘Central and North Coast Biodiversity, Mining and Tourism Area Order’ sets aside for a wide variety of uses other than

commercial timber harvesting. One of these areas overlaps with TFL 47 Block 12 on Sonora Island. This area (320 hectares) is excluded from the THLB (see Table 6.3).

Table 6.3 Biodiversity, Mining and Tourism Areas

TFL Region	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Johnstone Strait	320.3	0.0	320.3	133321

6.1.2 Non-Forest and Non-Productive Areas

Non-productive forest areas are portions of the land base capable of supporting vegetation but are considered unsuitable for growing commercial tree species. Non-forest areas are identified and removed from the THLB using the forest management land base indicator (FLMB) field in the VRI data. This attribute field indicates whether the polygon is forested or has been forested and can produce a stand of trees. These areas won't contribute to old seral constraints used to model biodiversity requirements.

Non-vegetated VRI polygons with no harvesting history are removed. This includes areas classified as 'non-vegetated land' or 'vegetated non-forest' according to the BCLCS. A small amount of 'treed' land is also removed due to a very low site index.

Table 6.4 Non-Forest and Non-Productive Forest Land

TFL Region	BCLCS Level 1	BCLCS Level 2	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Bonanza Lake	N	L	132.3	0.0	132.3	0
Bonanza Lake	N	W	1204.7	0.0	1204.7	0
Bonanza Lake	U		25.4	0.0	25.4	0
Bonanza Lake	V	N	862.7	0.0	862.7	779
Bonanza Lake	V	T	1075.9	0.0	1075.9	92655
Bonanza Lake	<blank>	<blank>	6.0	0.0	6.0	0
Johnstone Strait	N	L	24.6	0.0	24.6	48
Johnstone Strait	N	W	2169.6	0.0	2161.9	0
Johnstone Strait	U		125.7	0.0	125.5	0
Johnstone Strait	V	N	176.2	0.0	176.2	5
Johnstone Strait	V	T	323.8	0.0	323.8	22084
Johnstone Strait	<blank>	<blank>	53.9	0.0	53.9	0
Quadra Island	N	L	8.7	0.0	8.7	0
Quadra Island	N	W	219.5	0.0	219.5	0
Quadra Island	U		168.8	0.0	168.8	0
Quadra Island	V	N	27.3	0.0	27.3	0
Quadra Island	<blank>	<blank>	3.5	0.0	3.5	0
Total			6608.5	0.0	6600.6	115572

The TEM mapping also identifies non-productive areas not identified as such in the forest inventory. These areas have been netted out of the productive land base, as shown in Table 6.5.

Table 6.5 Non-Productive Site Series

TFL Region	NP Site Series	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Bonanza Lake	ES	20.0	0.0	20.0	5073
Bonanza Lake	GP	9.7	0.0	9.7	4678

TFL Region	NP Site Series	Area (ha)			Volume (m^3)
		Total	Productive	Removed	Removed
Bonanza Lake	LA	1151.9	0.0	22.7	2902
Bonanza Lake	LL	1.4	0.0	1.4	861
Bonanza Lake	RI	81.6	0.0	2.4	924
Bonanza Lake	RO	1224.3	0.0	467.7	18227
Johnstone Strait	BU	0.8	0.0	0.8	583
Johnstone Strait	ES	24.3	0.0	22.7	7035
Johnstone Strait	GP	3.9	0.0	2.6	590
Johnstone Strait	LA	2128.3	0.0	4.5	2585
Johnstone Strait	LL	16.1	0.0	16.1	5624
Johnstone Strait	PD	17.7	0.0	2.7	895
Johnstone Strait	RO	507.6	0.0	476.8	75887
Quadra Island	GP	2.0	0.0	2.0	34
Quadra Island	LA	203.6	0.0	0.8	117
Quadra Island	LL	1.5	0.0	0.2	29
Quadra Island	PD	19.2	0.0	4.2	112
Quadra Island	RO	924.3	0.0	923.5	120036
Total		6338.5	0.0	1980.8	246192

6.1.3 Existing and Future Roads, Trails and Landings

Roads have been identified using the spatial road database maintained by TimberWest. It is continuously updated as roads are built in support of harvesting operations. For MP#4, a total road width of 9.88 metres was used for Johnstone Straits / Quadra Island, and 10.33 metres was used for Bonanza Lake. These widths were based on field measurements made at the time. As there has been no change in road construction practices, these same buffer widths have been used for this analysis. The area within the GIS buffers has been removed from the THLB (Table 6.6). It is also considered to be non-productive.

Table 6.6 Existing Roads

TFL Region	Area (ha)		Volume (m^3)	
	Total	Productive	Removed	Removed
Bonanza Lake	1123.7	0.0	1105.8	298869
Johnstone Strait	2241.8	0.0	2232.8	593300
Quadra Island	358.4	0.0	349.3	116176
Total	3723.9	0.0	3687.9	1008346

TimberWest maintains that this traditional approach to road netdown significantly overestimates the impact of roads on timber supply. A road width analysis based on LiDAR data is currently underway. The work plan for that analysis is provided in Appendix H. Should this lead to a different estimate of the impact of forest roads on the THLB, a sensitivity analysis will be set up and run to gauge that impact.

Where existing road sections are not maintained or re-constructed, much of the area currently classified as rough roads and removed from the productive forest will eventually become overgrown by the forest. As the land base approaches a normal age class distribution, this increase in productive forest is roughly offset by permanent access structures needed to develop future harvest areas, and the overall disturbance is expected to remain reasonably stable over time. Thus, no future reductions for roads, trails, and landings will be applied in this analysis.

6.1.4 Inoperable Areas

The current operability map for the TFL was reviewed and confirmed before the last Management Plan and has since been updated by TimberWest staff using LiDAR data. It identifies large, contiguous areas that are uneconomical to harvest based on a combination of accessibility and timber value. It is considered accurate and suitable for strategic planning purposes. Stands that were primarily pulp, isolated, or old growth less than 250 m^3/ha were classified as inoperable. The total area that is considered inoperable or inaccessible is shown in Table 6.7

Table 6.7 Inoperable Areas

	Area (ha)		Volume (m^3)	
TFL Region	Total	Productive	Removed	Removed
Bonanza Lake	7295.4	4999.4	4999.4	940286
Johnstone Strait	4546.0	3748.7	3748.7	1457522
Quadra Island	494.9	232.2	232.2	67401
Total	12336.3	8980.4	8980.4	2465209

Areas with an 'Inoperable' designation that have been previously logged are considered operable. The remaining operable land base has been further classified according to yarding system.

TimberWest also updated their 'Helicopter Yarding' maps based on LiDAR data. These areas have not been removed from the THLB, but harvesting will be tracked in the forest estate model. Table 6.8 summarizes the area and timber volume only accessible by helicopter.

Table 6.8 Helicopter Yarding – Area and Volume

	Area (ha)			Volume (m^3)	
TFL Region	Total	Productive	THLB	Removed	THLB
Bonanza Lake	440.4	428.5	320.3	45967	46632
Johnstone Strait	741.5	639.0	134.3	279385	62021
Quadra Island	9.9	4.8	1.4	1071	378
Total	1191.7	1072.3	456.1	326424	109031

The operability map was reviewed to determine if any stands not classified as 'Inoperable' were practically isolated. No isolated stands were identified.

A further reduction to the operable land base was made; areas of 'Unstable' or 'Potentially Unstable' terrain were mapped, and a netdown was applied. For 'Unstable Terrain', two categories were excluded: 'Unstable' terrain and slope stability class 5. A 90% netdown was applied to these areas. Reductions have also been applied for 'Potentially unstable' and slope stability class 4; 20% of these areas were netted out of the THLB. Since they are partial land base netdowns, they are described in Section **Error! Reference source not found.**.

6.1.5 Non-Merchantable Forest Types

Stands with non-commercial leading species have been removed from the THLB, as shown in Table 6.9.

Table 6.9 Non-Commercial Leading Species

	Leading	Area (ha)			Volume (m^3)
TFL Region	Species	Total	Productive	Removed	Removed
Johnstone Strait	PL	1009.8	752.8	425.3	71068
Johnstone Strait	VB	356.8	335.6	335.6	25806
Quadra Island	PL	326.9	244.6	220.4	21550
Total		1693.4	1333.0	981.3	118424

Pine and any non-alder deciduous volume will also be removed from the yield curves for conifer-leading stands when they are formatted for the forest estate model.

6.1.6 Stands with Low Timber Growing Potential

Low-site stands are not likely to achieve a harvestable volume over a reasonable time horizon. Sites may fall into this category in two ways: they are inherently unproductive due to soil moisture and nutrient regimes (i.e. low site index); or the sites might not be fully occupied with commercial tree species. At this stage, the following stand types are netted out of the THLB:

- Immature coniferous stands incapable of achieving 150 m^3/ha at 150 years of age on slopes less than 30%;
- Immature coniferous stands incapable of achieving 250 m^3/ha at 150 years of age on slopes of 30% or more; and
- Immature deciduous stands incapable of achieving 150 m^3/ha have been netted out of the land base.

A lower volume threshold has been used on slopes less than 30%. These areas can be economically harvested using less expensive ground-based systems. Also, road construction costs tend to be lower.

This reduction is applied after Pl-leading and Vb-leading stands have been netted out of the land base as being non-commercial. To apply this reduction, stand volume at 150 years of age was forecast using Variable Density Yield Prediction (VDYP). The area netted out due to low growing potential is shown in Table 6.10, broken down by leading species.

Table 6.10 Low Timber Growing Potential – By Leading Species.

TFL Region	Leading Species	Area (ha)			Volume (m^3)
		Total	Productive	Removed	Removed
Bonanza Lake	BA	39.4	36.5	12.9	1616
Bonanza Lake	DR	5.7	3.9	0.8	22
Bonanza Lake	FD	6.0	5.8	5.8	0
Bonanza Lake	HM	4.9	2.0	0.1	4
Bonanza Lake	HW	25.0	24.5	18.3	1069
Bonanza Lake	YC	399.7	59.7	6.7	338
Johnstone Strait	CW	151.5	148.2	148.2	2814
Johnstone Strait	DR	126.2	109.0	109.0	11260
Johnstone Strait	FD	256.2	194.9	109.8	8477
Johnstone Strait	H	20.5	12.8	1.5	0
Johnstone Strait	HW	122.9	108.3	87.6	9453
Johnstone Strait	PL	729.3	479.6	0.0	0
Quadra Island	CW	29.6	29.6	29.6	1330
Quadra Island	DR	13.7	13.4	13.4	165
Quadra Island	FD	766.6	293.1	240.8	20460
Quadra Island	HW	7.3	4.8	4.8	333
Quadra Island	PL	287.7	205.6	0.0	0
Total		2992.2	1731.7	789.2	57340

6.1.7 Low Volume Mature Stands

Any stands older than 150 years that do not have at least 250m^3/ha are removed from the THLB, as shown in Table 6.11.

Table 6.11 Low-Volume Old Growth

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	7064.8	5569.7	2149.7	313735
Johnstone Strait	1606.8	1276.3	904.1	175643
Quadra Island	148.2	142.9	138.9	22348
	8819.8	6988.9	3192.7	511725

6.1.8 Wildlife Tree Retention / Stand-Level Biodiversity

Existing WTP's are mapped and have been excluded from the THLB. Categories in this layer are 'WTR' (wildlife tree retention) and 'RMA' (riparian management area). Table 6.12 shows how much area and volume was removed for both reasons.

Table 6.12 Existing Stand-Level Retention

TFL Region	Leading Species	Area (ha)			Volume (m^3)
		Total	Productive	Removed	Removed
Bonanza Lake	RMA	188.1	185.0	174.0	78895
Bonanza Lake	WTR	329.2	324.6	251.4	125981
Johnstone Strait	RMA	1574.4	1554.5	1533.7	801678
Johnstone Strait	WTR	1264.1	1253.0	1164.0	596130
Quadra Island	RMA	165.5	160.0	159.6	63947
Quadra Island	WTR	196.2	176.9	157.8	75825
Total		3717.6	3654.0	3440.5	1742456

Future WTP requirements will be dealt with partial netdowns in stands that do not already have mapped wildlife tree patches. An analysis of stand-level retention (See Appendix B) of recently harvested blocks found that in the GBRO area, 4.0% of cutblocks are retained in WTPs that are otherwise unconstrained. In the Non-GBRO, the on-block retention level is 2.8%.

6.1.9 Cultural Heritage Sites

Cultural heritage sites have been identified from two sources:

- information received by TimberWest from the provincial Archaeology Branch
- data collected by TimberWest during field work and or through information sharing (this will overlap with Archaeology Branch data in many cases)

Table 6.13 shows the area and volume that has been protected.

Table 6.13 Cultural Heritage Resources

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	4.5	4.5	4.5	4039
Johnstone Strait	124.0	120.7	87.0	42936
Quadra Island	5.6	4.2	4.1	1889
Total	134.1	129.4	95.6	48865

In addition to mapped heritage and archeological sites, culturally modified trees or other significant features may be identified during field layout. These are typically small in extent and are dealt with through operational planning measures (e.g., inclusion in wildlife tree patches), so they will not impact strategic timber supply.

TimberWest completes large cultural cedar (LCC) in conjunction with operation planning on Quadra Island in the GRRO area. When identified, they will be retained as part of the mandated stand-level retention so will not reduce strategic timber supply.

6.1.10 Riparian Areas

Areas adjacent to rivers, streams and other wetlands are classified as riparian. These riparian areas are essential as thermal cover for fish-bearing streams, habitat for wildlife, and protection of streambeds from erosion. The FSP commits to complying with FPPR Section 47 concerning riparian buffers. RRZ areas are excluded from harvesting.

TimberWest developed a riparian reserve spatial layer by buffering S1 to S3 streams based on Forest & Range Practices Act (FRPA) buffer widths (Table 6.14). The modelled RRZ width is calculated as the RRZ width plus the RMZ width times the percent retention. This initial layer was then adjusted to capture gully systems) using LiDAR slopes (though the LiDAR adjustment process was not applied to the Quadra Island Block). Table 6.15 shows the area and volume in these riparian reserve zones and the impact of their removal on the THLB.

Table 6.14 FPPR Riparian Buffering Rule for Fish-Bearing Steams

Riparian Class	Riparian Management Area (metres)	Riparian Reserve Zone (metres)	Riparian Management Zone (metres)	RMZ Retention (%)	Modelled RRZ Width (m)
S1-A	100	0	100	25	20
S1-B	70	50	20	25	55
S2	50	30	20	25	35
S3	40	20	20	25	25

Table 6.15 Mapped Riparian Reserve Zones

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	3290.6	2016.5	1545.3	766337
Johnstone Strait	4642.9	4352.9	2816.8	1410130
Quadra Island	548.4	299.6	196.8	80377
Total	8482.0	6669.0	4558.9	2256845

Retention for S4 to S6 streams was accounted for in conjunction with WTR in Section 6.1.8 above.

A further reserve zone has been established along the foreshore areas of Quadra Island. This 30-m buffer zone has been removed from the THLB.

Table 6.16 Quadra Island Foreshore

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Quadra Island	128.0	106.1	78.5	37884

No netdown is proposed for forested swamps. Forested swamps are infrequent within the plan area. Timber deferrals required for forested swamps will be handled operationally within WTPs.

The plan area has no fluvial units (fans, alluvial streams). The terrain is relatively gentle. Watersheds tend to be small and are usually regulated by lakes or wetlands.

6.1.11 Recreation Sites, Trails and Inventory

Protection of recreation values on the TFL does not fit the preceding categories. Two types of netdowns have been applied to protect recreation resources:

Features in the Recreation Inventory with 'High' or 'Very High' significance and 'High' sensitivity have been removed from the land base. The exception to this rule is karst features. The Recreation Inventory drew broad polygons around karst features; however, TimberWest staff feel that harvesting operations can be managed to protect these features without any negative impact on strategic timber supply. They have provided mapping for these areas used for the netdown described in Section 6.1.19.2.

Some features in the Recreation Inventory are partial netdowns and are described in Section 6.1.19.2.

Identified recreation sites and trails (buffered to 10 metres total width) have been netted out of the THLB.

In addition, two Recreation Areas were removed - Bonanza South and Ida Lake recreation sites.

Table 6.17 shows the total and productive area covered by recreation features, sites and trails and the THLB impacts of protecting them.

Table 6.17 Recreation Resources

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	610.9	107.9	15.6	9437
Johnstone Strait	43.7	42.4	34.8	17013
Quadra Island	32.2	21.9	19.8	8400
Total	686.7	172.2	70.2	34850

6.1.12 High-Value Fish Habitat

The GBRO identifies high-value fish habitat in which logging is prohibited. TimberWest maintains spatial data that identify these areas. This data was collected for the foreshore and estuaries in 2015 and is added for high-value stream areas as they are encountered in the field. The area and volume in these areas are summarized in Table 6.18.

Table 6.18 GBRO High-Value Fish Habitat

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Johnstone Strait	596.9	576.5	360.8	201528

6.1.13 Wildlife Habitat

No WHAs are currently established on Quadra or in Johnstone Strait. However, grizzly bear habitat has been identified (based on Schedule D of the GBRO). It is Type I Habitat and has been netted out of the THLB, as shown in Table 6.19.

Table 6.19 Grizzly Habitat

TFL Region	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Johnstone Strait	920.3	857.1	239.4	128043

The Bonanza Lake Block has UWRs for Black-tailed Deer and Roosevelt Elk (Table 6.20). WHAs for Marbled Murrelet and Northern Goshawk (Table 6.21) occur in both the Bonanza and GBRO zones. Harvesting is prohibited in all of these areas.

Table 6.20 Ungulate Winter Range

TFL Region	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Bonanza Lake	1014.6	999.7	809.8	440018

Table 6.21 Wildlife Habitat Areas

TFL Region	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Bonanza Lake	358.5	353.3	194.1	116086
Johnstone Strait	768.0	751.3	594.9	337034
	1126.5	1104.6	789.0	453120

Not all constrained Goshawk areas are included in WHAs. TimberWest manages for ‘no harvest’ Goshawk polygons that are not included in WHAs and are excluded from the THLB. This area is shown in Table 6.22.

Table 6.22 Goshawk Habitat

TFL Region	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Bonanza Lake	200.8	192.9	162.7	135690
Johnstone Strait	763.6	736.9	421.4	220053
	964.4	929.9	584.1	355743

6.1.14 Red Listed Habitat

Schedule N of the GBRO-designated red-listed plant communities that must be protected. These have been removed from the THLB, as shown in Table 6.23.

Table 6.23 Red-Listed Plant Communities

TFL Region	Area (ha) Total	Area (ha) Productive	Area (ha) Removed	Volume (m^3) Removed
Johnstone Strait	1709.0	1629.3	1080.6	420532

Blue-listed plant communities are also partially removed from the THLB. These are discussed in Section 6.1.19.1.

6.1.15 Karst Terrain

Karst terrain has been removed from the THLB based on field mapping compiled by TimberWest. Table 6.24 shows this netdown.

Table 6.24 Karst Terrain

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	122.3	116.8	100.1	27376

6.1.16 Bonanza Lake CWHvm1 Old Growth

The CWHvm1 BGC variant in the Bonanza Lake Block currently has insufficient old growth to satisfy the NSOGO. TimberWest has committed to no further harvesting of old-growth stands in these areas. They have been removed from the THLB, as shown in Table 6.25.

Table 6.25 Bonanza Lake CWHvm1 Old Growth

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	1368.5	1349.3	546.5	318675

6.1.17 Old Growth Management Areas

No Old Growth Management Areas (OGMAs) have been established on TFL 47.

6.1.18 Landscape Reserve Design

The landscape reserve design process is required to meet ecosystem-based management objectives in the GBRO area. The goals[3] for these reserve areas are:

1) To address the Minimum Old Forest Retention levels, Old Forest Representation Targets and Managed Forest area set out in the GBRO.

2) To the extent reasonably practicable, simultaneously contribute to the protection and stewardship of:

(i) Aboriginal Heritage Features, Aboriginal Forest Resources, and Cultural Cedar Use; and

(ii) Red-Listed and Blue-Listed Plant Communities, habitat important for species at risk, ungulate winter range, and habitat for regionally important wildlife, including, but not limited to mountain goats, grizzly bears, Northern Goshawks, tailed frogs, and Marbled Murrelets.

TimberWest has delineated significant landscape reserve areas within TFL 47 to meet these objectives. The impact of these on the THLB is shown in Table 6.26.

Table 6.26 Landscape Reserve Design

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Johnstone Strait	23129.7	21743.9	9912.3	4709061

[3] Taken from Ecosystem Based Management Implementation in the Great Bear Rainforest LANDSCAPE RESERVE DESIGN METHODOLOGY July 18, 2016 at https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/westcoast-region/great-bear-rainforest/great_bear_rainforest_landscape_reserve_design_methodology.pdf

6.1.19 Partial Netdowns

Partial netdowns have been applied for blue-listed habitat, recreation inventory polygons and terrain stability issues.

6.1.19.1 Blue-Listed Habitat

Seventy percent of the area in blue-listed plant communities identified in the GBRO have been removed from the THLB, as shown in Table 6.27.

Table 6.27 Blue-Listed Plant Communities – 70%

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Johnstone Strait	2533.9	2454.0	55.2	20846

Red-listed plant communities were netted out in Section 6.1.14.

6.1.19.2 Recreation Inventory

Features in the Recreation Inventory with ‘High’ or ‘Very High’ significance and ‘moderate’ sensitivity have been partially (70%) removed from the THLB, as shown in Table 6.28.

Table 6.28 Recreation Inventory – 50%

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	1783.8	1095.3	285.1	89837

Recreation inventory polygons with ‘high’ sensitivity were removed entirely from the THLB (see Section 6.1.11).

6.1.19.3 Unstable Terrain

TimberWest maintains maps showing areas of ‘Unstable’ or ‘Potentially Unstable’ terrain, and a suitable netdown has been applied. For ‘Unstable Terrain’, two categories were excluded: ‘Unstable’ terrain and slope stability class 5. A 90% netdown was applied to these areas. Reductions have also been applied for ‘Potentially unstable’ and slope stability class 4; 20% of these areas were netted out of the THLB. Table 6.29 and Table 6.30 show these netdowns.

Table 6.29 Unstable Terrain – 90%

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	2483.2	2017.8	534.8	258911
Johnstone Strait	1364.1	1085.8	97.0	43563
Quadra Island	15.9	6.4	0.3	150
Total	3863.2	3110.0	632.1	302624

Table 6.30 Potentially Unstable Terrain – 20%

TFL Region	Area (ha)			Volume (m^3)
	Total	Productive	Removed	Removed
Bonanza Lake	1941.5	1876.0	186.2	74696
Johnstone Strait	8436.6	7995.0	676.4	279529
Quadra Island	990.3	671.7	77.3	30798
Total	11368.3	10542.7	939.8	385024

7. Current Forest Management Assumptions

The base case timber supply scenario is intended to reflect current practice. This section describes those practices.

7.1 Harvesting

All harvesting will be clearcutting with reserves. An analysis of stand-level retention (See Appendix B) in blocks harvested in 2021 and 2022 shows that in the GBRO area, 4.0% of cutblocks are retained in WTPs that are otherwise unconstrained. In the Non-GBRO area, the on-block retention level is 2.8%.

7.2 Utilization Levels

The utilization level defines the maximum height of stumps that may be left in harvested areas and the minimum top diameter (inside bark) and minimum diameter (DBH) of stems that must be removed from harvested areas. These factors are needed to calculate merchantable stand volume for use in the analysis. The levels used in the analysis reflect current operational practice. Utilization standards will be:

- Stands older than 120 years: 30cm stump, 17.5cm DBH
- Stands younger than 121 years: 30cm stump, 12.5cm DBH

7.2.1 Stump Height

TimberWest has demonstrated that mechanical harvesting in second-growth stands (120 years old or younger) on lower slopes (below 45%) results in stumps shorter than the 30 cm assumption made in yield models. The analysis in Appendix A shows that the average stump height under these conditions is 20 centimetres.

7.3 Non-Commercial Component of Conifer-Leading Stands

Non-commercial species are not harvested, even where they occur in conifer-leading stands. These non-commercial species are lodgepole pine and all deciduous species except red alder.

7.4 Minimum Harvest Volume / Age

The minimum harvestable age (MHA) is the criterion that forest stands within an analysis unit must meet to be eligible for harvest. In most cases, economic factors will dictate the threshold beyond which stands are available for harvest. For the purpose of timber supply modelling, these characteristics are often expressed in terms of volume per hectare or average diameter. Culmination age, the age at which mean annual increment (MAI) reaches a maximum, or some proportion thereof, can also be used as the threshold for minimum harvestable age. In timber

supply modelling, the age at which the minimum threshold is attained is called the "minimum harvestable age" (MHA). These are minimum criteria – not rotation ages or the actual ages at which the stands will be harvested. Some stands may be harvested at the minimum thresholds to meet forest-level objectives; however, other stands may not be harvested until well past the age for "optimal" timber production due to management objectives for other resource values.

MHA is established for each analysis unit (AU). An AU is first harvestable when it meets the following criteria:

- 90% of culmination age; or
- 300 m^3/ha and 30 cm QMD.

This was the MHA approach used for MP#4. Alternative MHA limits will be examined in sensitivity analyses.

The MHA that results when these criteria are applied to each analysis unit (with no genetic gain applied) are shown in Table 7.1. This table shows the calculated MHA and the values of the three relevant criteria (volume per hectare, DBH and MAI) at that age. The table also shows the maximum (i.e., culmination) MAI and 90% of that value for comparison purposes. From the table values, the criteria limiting MHA for each AU can be determined.

Table 7.1 Minimum Harvest Age Calculation Detail – GG0

Analysis Unit	MHA	Height (m)	Volume (m^3/ha)	DBH (cm)	MAI (m^3/ha/year)	MAI Maximum (m^3/ha/year)	MAI Max *x* 90% (m^3/ha/year
B_CWHvm1_01_GG0	56	29.5	581	29.1	10.38	11.45	10.31
B_CWHvm1_02_GG0	69	26	438	26.1	6.35	7.02	6.31
B_CWHvm1_05_GG0	52	30	624	30	12	13.36	12.02
B_CWHvm2_01_GG0	64	28	548	29.4	8.55	9.44	8.49
B_CWHvm2_02_GG0	76	24.5	398	26.2	5.24	5.78	5.2
B_CWHvm2_05_GG0	61	28.5	572	30.1	9.38	10.39	9.35
B_CWHvm2_06_GG0	67	27.5	514	30	7.66	8.82	7.94
B_CWHvm2_09_GG0	86	25	372	30	4.33	5.06	4.56
B_MHmm1_01_GG0	90	23	339	26.1	3.77	4.18	3.76
J_CWHvm2_01_GG0	76	24.5	406	26.1	5.34	5.92	5.32
J_CWHxm_01_GG0	51	30	525	28.6	10.29	11.35	10.22
J_CWHxm_03_GG0	64	26	374	26.3	5.84	6.42	5.78
J_CWHxm_05_GG0	45	29.5	470	30.1	10.46	12.19	10.97
J_CWHxm_06_GG0	56	30.5	603	30.2	10.77	11.89	10.7
J_CWHxm_07_GG0	39	29	475	30	12.18	14.15	12.74
J_CWHxm_12_GG0	51	25.5	460	30.1	9.01	11.92	10.73
Q_CWHxm_01_GG0	50	28.5	444	27.4	8.89	9.87	8.88
Q_CWHxm_03_GG0	68	23.5	278	24	4.1	4.52	4.06
Q_CWHxm_05_GG0	47	30	466	30	9.91	11.57	10.41
Q_CWHxm_06_GG0	56	29.5	514	30.1	9.18	10.22	9.2
Q_CWHxm_07_GG0	44	30	480	30.3	10.91	12.85	11.56

Table 7.2 summarizes the calculated minimum harvest ages for all AUs across all genetic gain eras.

Table 7.2 Minimum Harvest Age Summary by Genetic Gain Era

Analysis Unit	GG0	GG1	GG2	GG3	GG4	GG5	GG6
B_CWHvm1-01	56	55	55	53	53	53	52
B_CWHvm1-02	69	68	68	65	65	64	64
B_CWHvm1-05	52	52	51	50	49	49	49
B_CWHvm2-01	64	63	63	63	63	63	62

Analysis Unit	GG0	GG1	GG2	GG3	GG4	GG5	GG6
B_CWHvm2-02	76	75	75	75	75	75	74
B_CWHvm2-05	61	61	61	61	61	61	60
B_CWHvm2-06	67	67	67	67	67	67	70
B_CWHvm2-09	86	86	86	86	86	86	89
B_MHmm1-01	90	90	90	90	90	90	86
J_CWHvm2-01	76	76	75	73	73	72	71
J_CWHxm-01	51	49	49	48	48	48	48
J_CWHxm-03	64	61	62	60	60	61	59
J_CWHxm-05	45	44	44	43	43	43	45
J_CWHxm-06	56	55	55	53	52	52	52
J_CWHxm-07	39	38	38	37	37	37	40
J_CWHxm-12	51	50	50	48	48	47	60
Q_CWHxm-01	50	49	49	48	48	48	48
Q_CWHxm-03	68	65	65	64	64	64	63
Q_CWHxm-05	47	46	46	45	45	45	47
Q_CWHxm-06	56	54	55	53	53	53	52
Q_CWHxm-07	44	42	43	42	42	42	45

Existing natural stands will be modelled on stand-by-stand yield tables, and they are too numerous to be presented in a tabular format. The same rules used to establish MHA for managed stands will be applied to existing stands.

7.5 Forest Health

The following forest heath concerns exist on TFL 47:

- Swiss Needle Cast
- Balsam Woolly Aphid
- Hemlock Dwarf Mistletoe
- White Pine Blister Rust
- Spruce Leader Weevil
- Phellinus and Armillaria Root Diseases
- Browsing (deer and elk)
- Drought

However, these exist at endemic levels and do not affect strategic timber supply. Endemic levels are inherent within the empirical basis of the growth and yield model VDYP, which is used for unmanaged stand yields (see 'Growth and yield' section). In volume tables produced by the model TIPSY, endemic levels are considered part of the operational adjustments modelled as standard for managed stands.

7.5.1 Climate Change

TimberWest is concerned about the potential long-term implications of climate change on its forestry holdings and has dedicated time and resources to understand the issue better. However, given the current scientific understanding, it is not yet possible to make reasonable quantitative predictions about the impact of climate change on timber supply. Therefore, the base case will not include specific accounting for climate change projections.

The potential impact of climate change on forests and forest management needs to be better understood. To that end, the provincial government has many initiatives underway. One of these is the "Climate Preparedness and Adaptation Strategy - Actions for 2022-2025", which makes the following statement:

> *The Ministry of Forests provides a good example of proactive action taking place in ministries. The Ministry considers and integrates climate change in their work, from day-to-day operations, changes to legislation and policy, to new approaches in foundational forest management systems for forest landscape planning and timber supply review. A climate adaptation policy framework will be developed to support this work. The Ministry is working together with regional offices and a network of researchers to increase the availability of climate science, adaptation tools and expertise to inform decision-making and operations.*

It further states that:

> *The Province is increasing climate science and adaptation expertise to support integration of climate change in key forest management and decision-making. This additional expertise will ensure that climate-relevant information is integrated and considered in foundational forest management systems such as planning and in the timber supply review – the process by which the Province's allowable annual cut is set – thereby strengthening the climate resilience of the forestry sector. Forest Landscape Plans, newly created by recent amendments to the Forest and Range Practices Act, provide a new mechanism for land managers to plan for future forest ecosystem conditions and to carry out practices and stand-level investments that contribute to managing global carbon cycles and climate change risks.*

TimberWest will continue monitoring these government-led initiatives and incorporate emerging information and understanding into strategic and operational planning. However, it is beyond the scope of the Management Planning process to comment on the provincial government's climate change strategy.

7.6 Unsalvaged Losses

No allowance for non-recoverable losses (NRL) was applied for the timber supply analysis completed in conjunction with MP#4, and none are proposed for this analysis. Managed stand yield tables already take small openings due to windthrow (and other causes) into account by applying an operational adjustment factor (OAF). Modelling NRLs during forest estate modelling would result in 'double-counting' these losses.

7.7 Resource Management Objectives

7.7.1 Seral Stage Distribution

There are no legally established OGMAs on TFL 47. Old seral targets specified in the Non-Spatial Old Growth Order will be met for the non-GBRO portions of the TFL. These need to be achieved at the BGC variant and landscape unit level. The area in each of these categories is shown in Table 7.3.

Table 7.3 Old Seral Management Zones – Non-GBRO Area

TFL Block	Landscape Unit	BGC Variant	Area (ha)		
			Total	Productive	THLB
12	Quadra	CWHdm	34	25	23
12	Quadra	CWHmm1	639	547	466
12	Quadra	CWHvm1	27	18	17
12	Quadra	CWHxm2	10,146	8,548	7,058

TFL Block	Landscape Unit	BGC Variant	Area (ha)		
			Total	Productive	THLB
17	Bonanza	CWHvm1	15,665	13,678	10,421
17	Bonanza	CWHvm2	10,574	10,093	7,289
17	Bonanza	CWHxm2	5	4	2
17	Bonanza	MHmm1	8,821	8,100	3,115
17	Bonanza	MHmmp1	1,542	984	30

Old seral targets are established based on BGC zone and natural disturbance type, as shown in Table 7.4.

Table 7.4 Old Seral Targets for Low/Intermediate BEO

Natural Disturbance Type	Biogeo-climatic Zone	Age of Old Forest	Percent Old Forest Retention
1	CWH	>250 years	>13
1	MH	>250 years	>19
2	CWH	>250 years	>9

In addition to these old seral requirements, a mature+old seral requirement will be applied to the Quadra SMZ. At least 25% of the productive forest land base must be occupied by stands in a mature (or older) seral condition.

The GBRO area is not subject to the NSOGO. All seral requirements for this area are deemed to be met by the landscape reserve design and other mature stands outside of the THLB.

7.7.2 Adjacency, Green-Up and Patch Size Distribution

For most of the TFL, cutblock size will be limited to 40 hectares. For this purpose, a cutblock is defined as any connected openings occupied by trees less than three metres tall. This is the FPPR default maximum cutblock size.

This restriction will be relaxed for the Bonanza Lake area, which falls entirely within a VILUP EFZ. The cutblock size will not be limited, and the green-up height will be reduced to 1.3 metres. Cutblock size will be tracked during forest estate modelling, and size limits may be applied if blocks become too large. The layout of large blocks (greater than 40 hectares) is operationally guided by commitments made in the FSP.

For the Quadra SRMZ, a maximum opening size of five hectares will be enforced.

7.7.3 Wildlife Habitat

All wildlife habitat concerns are managed through a system of reserves and netdowns, so no forest cover constraints are required. None of the WHA or UWR areas in TFL 47 have a ‘Conditional Harvesting’ designation. Harvesting is prohibited, and they have been removed from the THLB.

The Ministerial Order ‘*Order for the Recovery of Marbled Murrelet*’ was reviewed. It was determined that it would have no impact on strategic timber supply on TFL 47. No modelling measures are required.

7.7.4 Visual Quality

The visual landscape inventory identifies known scenic areas in TFL 46. Visually sensitive areas are summarized by Recommended Visual Quality Class (RVQC) and Visual Absorption Capacity (VAC) in Table 7.5. Visual quality will be maintained by limiting the rate of cut for each visually sensitive polygon according to the limits in Table 7.5.

Cover constraints to protect visual resources will be applied by RVQC category and VAC. The visually effective green-up (VEG) height is 5 metres in all cases. Table 7.5 shows the maximum allowable disturbance (%)permitted in each case.

Table 7.5 Disturbance Limits (%) by VQO and VAC

Recommended Visual Quality Class	Visual Absorption Capacity		
	Low	Medium	High
Retention	3	5	5
Partial Retention	10	15	15
Modification	20	25	25

There are 258 separate polygons on TFL 47 that fall into one of these VQO/VAC categories. These are summarized by VQO and VAC in Table 7.6.

Table 7.6 Area by VQO and VAC Categories

TFL Zone	VQO	VAC	Area (ha)		
			Total	Productive	THLB
Bonanza Lake	PR	M	863	833	624
Johnstone Strait	M	H	4,606	4,424	3,132
Johnstone Strait	M	L	486	479	219
Johnstone Strait	M	M	7,224	6,812	4,239
Johnstone Strait	PR	H	4,491	4,317	2,896
Johnstone Strait	PR	L	604	589	235
Johnstone Strait	PR	M	14,177	13,422	8,020
Johnstone Strait	R	H	225	215	168
Johnstone Strait	R	L	253	251	40
Johnstone Strait	R	M	1,777	1,458	592
Quadra Island	M	H	288	272	248
Quadra Island	M	L	16	16	10
Quadra Island	M	M	1,113	1,010	904
Quadra Island	PR	H	109	91	76
Quadra Island	PR	L	186	151	134
Quadra Island	PR	M	2,141	1,689	1,263
Quadra Island	R	H	553	363	265
Quadra Island	R	L	31	28	17
Quadra Island	R	M	240	193	125

7.7.5 Quadra SRMZ

Within the Quadra SMZ (established by VILUP Higher-Level Plan Order in 2000), TimberWest has committed to ensuring that the proportion of the forested land base in a mature seral condition does not fall below 25%.

7.7.6 GBRO Objectives

The GBRO sets many other forest management objectives that have been considered in preparing this Information Package. The following objectives are noted here but are deemed to be met through the Landscape Reserve Designs that have been put into place:

- Ecosystem Representation and Landscape Level Biodiversity (Part 1 - Section 4, and Schedule G)
- Type 1 Restoration Landscape Units – Thurlow, Gilford, Fulmore, Gray (Part 1 - Section 7, and Schedule H)

- Aboriginal Forest Resources (Part 3 – Section 5, and Schedule J)
- Aboriginal Heritage Features (Part 3 – Section 6 and Schedule I)
- Aboriginal Tree Use (Part 3 – Section 8)

The following objectives will be met through operational planning measures

- High-Value Fish Habitat (Part 3 – Section 11)
- Aquatic Habitat that is not High-Value Fish Habitat (Part 3 – Section 12)
- Forested Swamps (Part 3 – Section 8)
- Upland Streams (Part 3 – Section 14 and Schedule E)
- Active Fluvial Units (Part 3 – Section 15)
- Black Bear Dens (Part 3 – Section 19)

The following objectives will be met through reductions to the THLB:

- Red-Listed and Blue-Listed Plant Communities (Part 3 – Section 16)
- Grizzly Bear Habitat (Part 3 – Section 18)

Stand-level retention objectives (Part 3 – Section 17) will be met through an aspatial set-aside of 4.0%. This factor was calculated by reviewing a recent sample of cutblocks to determine the proportion of each that has been retained for stand-level retention that would not have been retained for any other reason.

Objectives for Important Fisheries Watersheds (Part 3 – Section 10, and Schedule E) will be met by restricting the equivalent clearcut area (ECA) to 20%. Table 7.7 shows the designated watersheds and their associated areas.

Table 7.7 Important Fisheries Watersheds

	Area (ha)		
Watershed Name	Total	Productive	THLB
Camelion Harbour Creek	746	692	322
Christie Creek	502	469	144
Fulmore River & Tributaries	126	124	66
Grassy Creek	750	737	438
Hemming Lake Creek	601	576	334
Jackson Bay Creek	489	464	317
Knox Bay Creek	80	79	50
Owen Creek	60	17	5
Read Creek	264	256	200
Schoal Creek	33	32	14
Thurston Bay Creek	514	497	303
Tuna River	27	27	12
Unnamed Stream-Sonora Island	409	390	349
Wortley Creek	679	582	246

7.7.7 Other Objectives

Some other resource objectives commonly modelled for other tenures do not occur on TFL 47. Specifically:

- No Community Watersheds exist.
- No harvesting is permitted in any wildlife habitat areas (WHAs) or ungulate winter range (UWR) areas.

8. Growth and Yield

Stand-level growth and yield forecasts are necessary inputs for forest estate modelling. Growth and yield models are used to generate these forecasts of volume and other stand characteristics. Inputs for these models come from many different databases, including: forest inventory, silvicultural history and ecosystem mapping.

At the time of the last AAC determination (MP#4), the Chief Forester provided two implementation instructions. Both were related to uncertainty around yield forecasts. These were:

1) TimberWest should work with FLNR staff to implement a young stand monitoring (YSM) program to confirm that the managed stand yield estimates for TFL 47 are sustainable in practice.
2) TimberWest should provide information that confirms the natural stand volume estimates and projections that will be used in the timber supply analysis for the next AAC determination.

Regarding the first instruction, TimberWest has undertaken a new inventory of their private lands and public tenures, including TFL 47. This project is still underway, but compiled field plot data from TFL 47 was made available for this analysis. Although the volume differences were not statistically significant (95% confidence level), the fact remains that the inventory volumes were 29.5% (or 59.8 m^3/ha) higher than the MP#4 yield curve volumes.

In response to the second instruction, harvest volumes from blocks completed in 2019, 2020 or 2021 were compared to the volumes predicted for those blocks based on the MP#4 natural stand yield tables. The average volume per hectare estimates (for all blocks) from each source differed by less than one percent.

A report documenting the methods and results of both foregoing analyses was prepared and submitted to the MoF for their consideration. The same datasets (i.e., compiled field plots and scale/waste/leave volumes) will be used to assess the yield curves used for the MP#5 timber supply analysis.

8.1 Volume Table Types

Volume tables can be developed for single stands or for aggregations of stands with common or similar attributes. The latter aggregations are commonly referred to as analysis units. Natural stand yield tables will be compiled on a stand-by-stand basis. Managed stand yield forecasts will be developed for analysis units based on region and site series groups

8.2 Growth and Yield Models

This section describes the issues, information sources, assumptions, methods, and any relevant processing or adjustments related to growth and yield estimates for existing and future stands.

All yield tables – for both natural and managed stands – will be submitted to the MoF for review and acceptance before being used for forest estate modelling.

8.2.1 VDYP

Natural stand yield tables have been compiled using Variable Density Yield Prediction (VDYP) Batch version 7.33b. It is an empirical growth model based on temporary and permanent sample plot data. The utilization level for mature stands (older than 120 years) is 17.5 cm DBH. Younger stands have a lower DBH cutoff – 12.5 cm DBH. A 30 cm stump and 10 cm top diameter are assumed in both cases.

8.2.2 TIPSY

Managed stand yield tables have been compiled using the Table Interpolation Program for Stand Yields (TIPSY) model, which provides yield tables for single-species and even-aged stands based on the interpolation of yield tables generated by the individual tree growth model tree and stand simulator (TASS). Mixed species yield tables generated by TIPSY are weighted averages of single-species yields and do not directly consider inter-species interactions. The utilization limits are 12.5 cm DBH, 30 cm stump and 10 cm top diameter.

Existing and future managed stands have been developed for each analysis unit in Table 8.1. These AUs are based on region (Bonanza Lake, Johnstone Strait and Quadra Island) BGC variant and site series. More than one variant or site series can be included in an AU, as the table shows. A planted and a natural (ingress) curve will be complied for each AU. The percentage that each component will contribute to the final harvest volume is shown in the last two columns of the table.

Table 8.1 Analysis Unit Definitions

AU Name	BGC Variants	Site Series	Planted %	Natural %
B_CWHvm1_01	CWHvm1	01	28	72
B_CWHvm1_02	CWHvm1	02, 03, 04	28	72
B_CWHvm1_05	CWHvm1	05, 07, 08	33	67
B_CWHvm2_01	CWHvm2	01	21	79
B_CWHvm2_02	CWHvm2	02, 03, 04	32	68
B_CWHvm2_05	CWHvm2	05, 07, 08	32	68
B_CWHvm2_06	CWHvm2	06	60	40
B_CWHvm2_09	CWHvm2	09, 10, 11	49	51
B_MHmm1_01	MHmm1	All	19	81
J_CWHvm2_01	CWHvm2, MHmm1, CWHmm2	All	34	58
J_CWHxm_01	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	01	75	25
J_CWHxm_03	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	02, 03	78	22
J_CWHxm_05	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	04, 05	87	13
J_CWHxm_06	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	06	68	32
J_CWHxm_07	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	07, 08	79	21
J_CWHxm_12	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	12, 14	37	63
Q_CWHxm_01	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	01	44	56
Q_CWHxm_03	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	02, 03	49	51
Q_CWHxm_05	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	04, 05	77	23
Q_CWHxm_06	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	06	39	61
Q_CWHxm_07	CWHxm, CWHxm2, CWHdm, CWHvm1, CWHmm1	07, 08	77	23

All existing natural stands will regenerate to one of these analysis units based on its BEC zone/subzone/variant and site series. Existing old-growth and existing second-growth stands will be treated similarly – they will have the same silviculture prescriptions and regeneration assumptions applied. All stands harvested since 1975 have been assigned to one of these analysis units; no historic NSR exists.

The site index that drives the yield forecast for each AU is the area-weighted average SI for all the stands that will regenerate to the AU.

Table 8.2 TIPSY Input Parameter for MSYT

Analysis Unit	SI	Sp1	Sp2	Sp3	Sp4	Pct1	Pct2	Pct1	Pct4	Density	Regen Method
B_CWHvm1_01	27	Cw	Fd	Ba	Yc	68	18	7	7	1000	P
B_CWHvm1_01	31	Hw	Ba	Cw		85	8	7	0	5606	N
B_CWHvm1_02	20	Cw	Fd	Ba	Yc	68	18	7	7	1000	P
B_CWHvm1_02	24	Hw	Ba	Cw		85	8	7	0	5606	N
B_CWHvm1_05	29	Cw	Ba	Ss	Fd	82	9	6	3	1000	P
B_CWHvm1_05	33	Hw	Ba			97	3	0	0	4890	N
B_CWHvm2_01	26	Yc	BA	Fd	Cw	70	10	10	10	900	P
B_CWHvm2_01	26	Hw	Ba	Yc	Hm	44	28	22	6	5022	N
B_CWHvm2_02	20	Yc	Fd	Cw	Ba	78	16	3	3	900	P
B_CWHvm2_02	20	Hw	Ba	Cw	Hm	60	29	10	1	6898	N
B_CWHvm2_05	27	Yc				100	0	0	0	900	P
B_CWHvm2_05	27	Hw	Ba	Hm		65	34	1	0	4030	N
B_CWHvm2_06	24	Yc	Ba	Cw		91	7	2	0	900	P
B_CWHvm2_06	24	Hm	Ba	Hw		37	35	28	0	2184	N
B_CWHvm2_09	18	Yc	Ba	Cw		82	10	8	0	900	P
B_CWHvm2_09	18	Hm	Yc	Hw	Ba	37	37	16	10	976	N
B_MHmm1_01	16	Yc	Ba			85	15	0	0	800	P
B_MHmm1_01	16	BA	Yc	Hw	Hm	41	35	14	10	3953	N
Q_CWHxm_01	32	Fd	Cw			98	2	0	0	1000	P
Q_CWHxm_01	28	Hw	Fd	Pw		51	47	2	0	4480	N
Q_CWHxm_03	23	Fd	Cw	Pw		96	2	2	0	1000	P
Q_CWHxm_03	18	Hw	Fd	PL	Pw	48	24	18	10	2805	N
Q_CWHxm_05	36	Fd	Cw			87	13	0	0	1000	P
Q_CWHxm_05	29	Hw	Fd			64	36	0	0	1459	N
Q_CWHxm_06	33	Fd	Cw			85	15	0	0	1000	P
Q_CWHxm_06	25	Cw	Hw			66	34	0	0	2190	N
Q_CWHxm_07	39	Fd	Cw			87	13	0	0	1000	P
Q_CWHxm_07	30	Hw	Fd			64	36	0	0	1459	N
J_CWHvm2_01	18	Cw	Fd	Hw	Ba	100	0	0	0	1000	P
J_CWHvm2_01	22	Hw	Cw	Ba	Fd	50	26	24	0	4006	N
J_CWHxm_01	33	Fd	Cw	Hw	Ba	89	11	0	0	1100	P
J_CWHxm_01	30	Hw	Cw	Pw	Fd	88	11	1	0	2832	N
J_CWHxm_03	26	Fd	Cw	Hw	Ba	97	3	0	0	1100	P
J_CWHxm_03	22	Hw	Cw	PL	Fd	55	41	4	0	2128	N
J_CWHxm_05	36	Fd	Cw	Dr	Hw	79	20	1	0	1100	P
J_CWHxm_05	31	Hw	Dr	Cw	Ss	85	13	1	1	1107	N
J_CWHxm_06	28	Cw	Fd	Ba	Ss	66	32	1	1	1100	P
J_CWHxm_06	32	Hw	Cw	Ss	Fd	72	27	1	0	2648	N
J_CWHxm_07	39	Fd	Cw	Hw	Ba	58	42	0	0	1100	P
J_CWHxm_07	33	Hw	Dr	Ss	Fd	57	42	1	0	1205	N
J_CWHxm_12	28	Cw	Fd	Hw	Ba	100	0	0	0	1000	P
J_CWHxm_12	28	Cw	Hw	Ss	Fd	83	14	3	0	1535	N

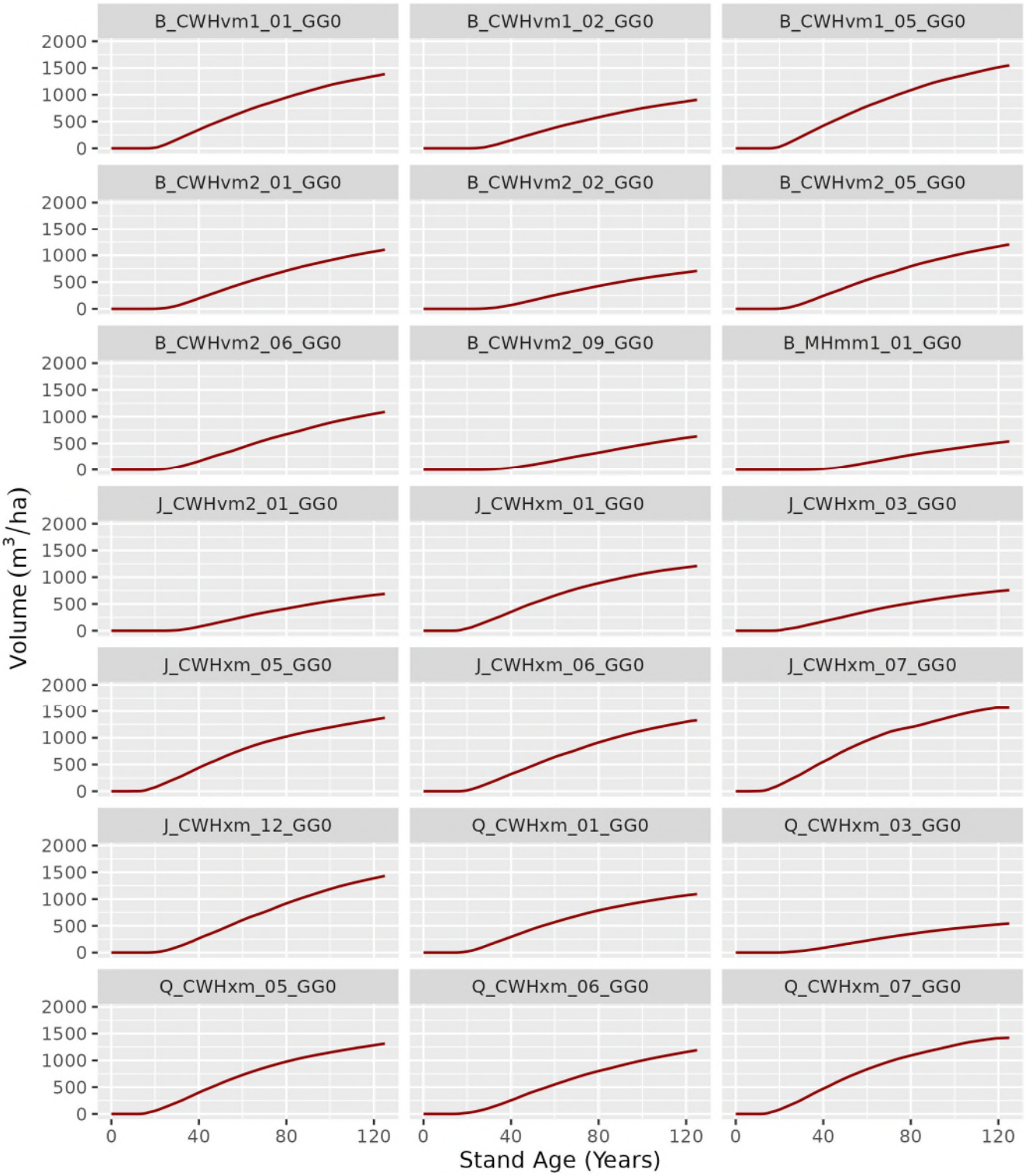


Figure 8.1 TIPSY Managed Stand Yield Tables – No Genetic Gain

8.3 Site Index

A site index adjustment (SIA) program was completed on TFL 47 following MP #3 to provide improved site index estimates for managed stands based on a field data collection program and a Terrestrial Ecosystem Mapping (TEM). These estimates of site productivity have been used to develop yield curves for existing and future managed stands for this analysis. The report describing the site index adjustment process can be found in Appendix D.

8.4 Tree Improvement

Improvements in growth due to the use of genetically improved seed have been modelled during yield curve construction. Genetic gains will be applied to any stands established after 1999. For MP#3, 8% and 5% were used for all post-1999 Fd and Cw stands, respectively. These gains will be used for stands established between 1999 and 2004 for this analysis. The MP#4 planning process, calculations were made using seedlot information in planting records to set new Fd, Cw and Ba genetic gain factors for stands established between 2005 and 2009. For this analysis, genetic gain calculations have been made for three more eras: 2010-2014, 2015-2019, and 2020-2022. Factors for all future stand yield curves are based on 2023 sowing requests. These are summarized in Table 8.3 Genetic Gain by Silviculture Era and Species.

Table 8.3 Genetic Gain by Silviculture Era and Species

GG Era	Range	Fd	Cw	Hw	Ba	Dr
GG0	before 2000	0	0	0	0	0
GG1	2000 - 2004	8	5	0	2	0
GG2	2005 - 2009	7.1	6.8	0	0.7	0
GG3	2010 - 2014	11	21	0	0	0
GG4	2015 - 2019	11	22	10	0	32
GG5	2020 - 2022	11	24	9	0	32
GG6	2023 +	13	24	15	0	32

8.5 Incremental Silviculture

There has been no incremental silviculture practiced on the TFL that would have an impact on strategic timber supply. None is planned.

8.6 Operational Adjustment Factors

Operational adjustment factors (OAFs) are applied in order to adjust managed stand yields generated by TIPSY to reflect such factors as gaps in stands and decay in trees. OAF1 is a constant percentage reduction to account for stand openings, distribution of stems, endemic pests and diseases, and other risks to potential yield. OAF2 is an increasing percentage reduction that can be applied to account for decay, waste and breakage.

The default factors most commonly used are an OAF1 of 15 percent and an OAF2 of 5 percent. Those values have been used for this analysis. A more realistic OAF1 value will be derived from survey and other data and may be used to generate managed stand yield tables for a sensitivity analysis.

8.7 Regeneration Delay

All blocks are planted within one year of harvest completion using one-year-old stock. A regeneration delay of zero years has been used for yield curve construction. Any alternative regeneration delay assumptions will be applied in the forest estate model rather than the growth and yield models.

Instead, silviculture survey data has been reviewed to find the average number of years it takes to reach breast height for each analysis unit. Section 8.8.1 describes this work.

Alternative regen delay levels may be tested in sensitivity analysis runs in the forest estate model.

8.8 Yield Table Adjustments

Adjustments will be made to managed stand yield tables to account for TIPSY-predicted and survey-determined years-to-breast-height. Adjustments will be made to all second-growth yield tables to account for the lower stump heights achieved when cutblocks are mechanically harvested. Yield curves for conifer-leading stands will also be reduced to remove the volume of any uncommercial species component.

8.8.1 Years to Breast Height

Appendix F describes the analysis work undertaken to determine the average number of years trees take to reach breast height. Averages from silvicultural surveys were compiled by AU and compared to the TIPSY-generated years-to-breast height estimates. The results are summarized in Table 8.4.

Table 8.4 Years to Breast Height – TIPSY and Silvicultural Surveys

	TIPSY							Silviculture Survey		
Analysis Unit	GG0	GG1	GG2	GG3	GG4	GG5	GG6	**Fdc**	**Cw**	**Hw**
B_CWHvm1-01	6	6	6	6	6	6	6			3.2
B_CWHvm1-02	7	7	7	7	7	7	7			
B_CWHvm1-05	6	6	6	6	6	6	6			
B_CWHvm2-01	6	6	6	6	6	6	7			
B_CWHvm2-02	7	7	7	7	7	7	8			
B_CWHvm2-05	6	6	6	6	6	6	7			
B_CWHvm2-06	6	6	6	6	6	6	7			
B_CWHvm2-09	7	7	7	7	7	7	8			
B_MHmm1-01	8	8	8	8	8	8	9			
J_CWHvm2-01	7	7	7	7	7	7	8			6.1
J_CWHxm-01	5	5	5	5	5	5	6	3.5	4.3	3.8
J_CWHxm-03	5	5	5	5	5	5	7	4.1		
J_CWHxm-05	4	4	4	4	4	4	5	3.3	4.0	3.2
J_CWHxm-06	6	6	6	6	6	6	6		4.5	4.5
J_CWHxm-07	3	3	3	3	3	3	4	3.6	3.5	3.7
J_CWHxm-12	6	6	6	6	6	6	8			
Q_CWHxm-01	5	5	5	5	5	5	7	4.3	4.8	3.5
Q_CWHxm-03	6	6	6	6	6	6	7			
Q_CWHxm-05	5	5	5	5	5	5	6	3.8		
Q_CWHxm-06	5	5	5	5	5	5	7		3.6	
Q_CWHxm-07	4	4	4	4	4	4	6			

Based on these results, there is justification for shifting the managed stand yield tables either leftward or rightward on the age axis to align them with RESULTS survey data. The 'Age-Shift' column in **Error! Reference source not found.** Table 8.5 shows the adjustment that will be made.

Table 8.5 Difference in Years to Breast Height – TIPSY vs Silvicultural Surveys

Analysis Unit	TIPSY	Fdc	Cw	Hw	Age Shift
B_CWHvm1-01	6			3.2	-2
B_CWHvm1-02	7				
B_CWHvm1-05	6				
B_CWHvm2-01	6				
B_CWHvm2-02	7				
B_CWHvm2-05	6				
B_CWHvm2-06	6				
B_CWHvm2-09	7				
B_MHmm1-01	8				
J_CWHvm2-01	7			6.1	-1
J_CWHxm-01	5	3.5	4.3	3.8	-1
J_CWHxm-03	5	4.1			
J_CWHxm-05	4	3.3	4.0	3.2	
J_CWHxm-06	6		4.5	4.5	-1
J_CWHxm-07	3	3.6	3.5	3.7	1
J_CWHxm-12	6				
Q_CWHxm-01	5	4.3	4.8	3.5	
Q_CWHxm-03	6				
Q_CWHxm-05	5	3.8			-1
Q_CWHxm-06	5		3.6		-1
Q_CWHxm-07	4				

8.8.2 Stump Height

Appendix A shows the results of a stump height analysis that demonstrates that stumps on mechanically harvested, second-growth cut blocks on lower slopes are significantly shorter than is assumed by TIPSY (20 cm versus 30 cm). Since stump height is not a tunable parameter in TIPSY, an external approach to developing an adjustment factor was developed.

TIPSY output includes site height and quadratic mean diameter at each age. This was taken to represent the ‘average tree’ for that analysis unit at that age. Kozak’s table equation was used on that average tree to calculate its merchantable volume from a 20 cm stump and a 30 cm stump. The ratio between these two tree volumes – minus one – represents the proportional volume gain by logging down to a 20-cm stump. Multiplying this factor by the net merchantable volume per hectare for the AU at that age results in the ‘extra’ volume per hectare curves shown in Figure 8.2. At 80 years of age, the increase in harvest volume per hectare ranges from 5.9 to 33.6 cubic metres. The average gain is 13.9 m^3/hectare – an increase of 1.9%.

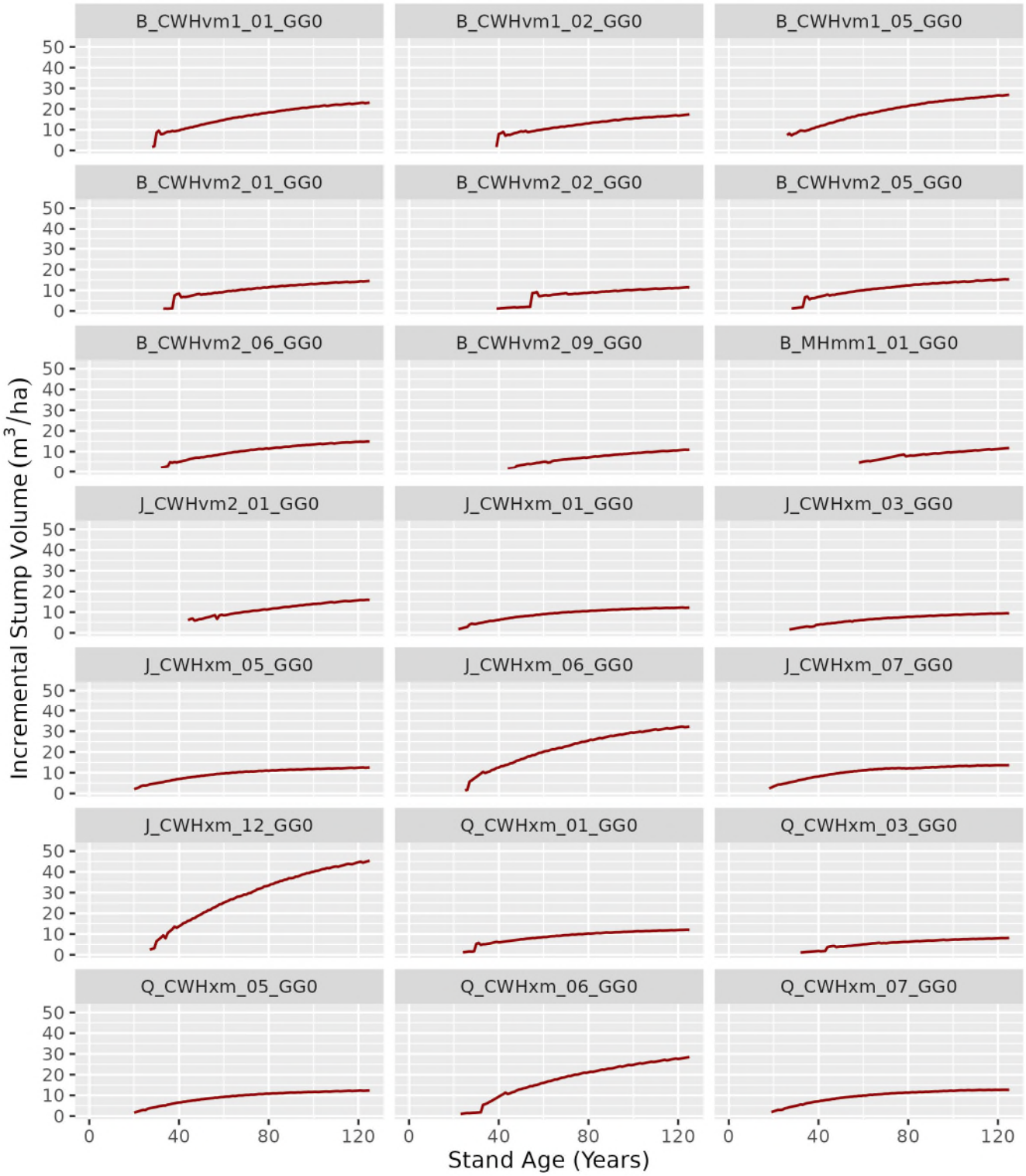


Figure 8.2 TIPSY MSYT – 'Extra' Stump Volume

9. Forest Estate Modelling

9.1 Forest Estate Model

Patchworks is a spatially explicit harvest scheduling optimization model developed by Spatial Planning Systems in Ontario. It has been used to develop spatially explicit harvest allocations to explore the trade-off between a broad range of conflicting management and harvest goals. Patchworks is a multiple-objective goal-programming model and can be described as consisting of two components:

- A GIS interface with map viewer and viewer functions; and
- A harvest scheduler that runs continuously in the background - searching for improvements in the allocation to improve the value of the objective function.

The model seeks a solution that maximizes the value of the total objective function. The objective function will be made up of both the traditional (management plan) objectives and the additional requirements and indicators. In timber management areas, the harvest schedule will be optimized (both the current and future forecasted land base) for timber flow requirements and to minimize environmental risk, as measured by the established indicators.

9.2 Base Case

The base case analysis uses the best available information and assumes that current management practices will be carried on throughout the entire 250-year planning horizon. It is intended to model 'What is?' rather than 'What if?'. Major forest management considerations and issues incorporated into this base case analysis are:

- Vegetation Resources Inventory (VRI) data, including the Phase II / NVAF adjustment;
- minimum harvest ages based on volume and piece size criteria and on the culmination of merchantable volume;
- exclusion of harvesting within Ungulate Winter Range (UWR), Riparian Reserves Zones (RRZ) and other areas with high habitat or recreational values;
- implementation of Ecosystem-based management in the region covered by the GBRO
- buffering of all unreclaimed roads in the road inventory to reflect the loss of productive area;
- constraints on harvest rates to protect biodiversity and visual values at the landscape level;
- retention of trees to meet stand-level biodiversity and riparian requirements; and
- regeneration and silvicultural assumptions that reflect current practices.
- adjusting managed stand yield curves to agree with observed (from RESULTS data) years-to-breast-height

It is based on current performance, and so provides a reference timber supply forecast against which timber supply implications of different future management options may be measured. The objective of the base case will be to:

- Harvest at the current AAC level for as long as possible;
- Increase harvest levels at the earliest time that it can be done sustainably;
- Increase the initial harvest level if it can be done without lowering mid or long-term harvest levels

- Limit changes in harvest level to less than 10% per decade.

9.3 Sensitivity Analysis

Sensitivity analysis provides a measure of the upper and lower bounds of the base case harvest forecast that reflects the uncertainty in the data or the management assumptions made in the base case. The magnitude of the increase and decrease in the sensitivity variable demonstrates the degree of uncertainty surrounding the assumption associated with that specific variable. This provides a way to gauge how much the base case harvest level and other statistics might change with changes to input data and assumptions.

Table 9.1 summarizes the sensitivity analyses that will be performed for this analysis.

Table 9.1 List of Sensitivity Analyses

Issue	Sensitivity Analysis	Level to be Tested
Land Base Uncertainty		
Impact of roads on productive land base is overestimated	Reclassify roads and recalculate buffer widths	+/- 10%
Old Growth Harvesting	Prohibit harvesting in TAP polygons	n/a
Stand G/Y Uncertainty		
Inventory volumes not realized at harvest	Existing Stand Volume	+/- 10%
	NSYT with Phase 2 Adjustment	
Future stands do not perform as forecast	Future Stand Volume	+/- 10%
Stands become economical to harvest sooner or later than predicted	Minimum Harvest Age	+/-10, +20 years,
Shorter stump heights aren't achievable	Use 30 cm stump height everywhere	n/a
Disturbance Limit Uncertainty		
Visual Constraints	Green-up Height	+/- 1 m
Regeneration Uncertainty		
TEM SI does not accurately reflect future site productivity	Use SIBEC Site Index to build yield curves	n/a
Regenerated stocking exceeds TIPSY assumptions	Reduce OAF [4]1 for Managed Stand Yield Tables	-5%
Management Objective Uncertainty		
Old seral targets	Assume OG is reduced due to non-THLB disturbance	n/a
AAC might be partitioned	Model Bonanza and Quadra blocks separately	n/a

[4] Operational Adjustment Factor

Appendix A

Average Stump Height Calculations

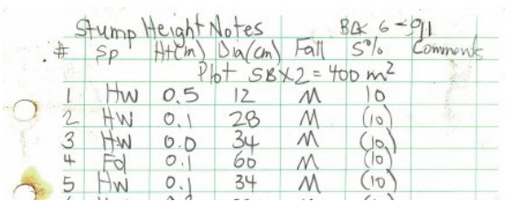
TFL 47 Stump Height Analysis

May 18, 2023

Methodology & Results

Beginning in 2015, stump height data was collected at the same time as the waste assessments were conducted in TFL 47. The methodology used to complete the waste assessments followed the *Provincial Logging Residue and Waste Measurements Procedure Manual – Coast Version*[1], in effect on the date of the assessment. The dispersed and accumulation subpopulations are sampled using fixed-area sample plots laid out systematically. The stump height data was collected at each of these fixed-area sample plots established for the purposes of completing waste assessments (see **Figure 1**).

Figure 1. Sample field card showing the stump height data collected.



The data collected on the sample field card, shown in **Figure 1**, was manually entered into an Excel spreadsheet titled '*TFL 47 Stump Height Analysis*' (**Figure 2**). Additional data on the plot location (Slash (dispersed subpopulation) or Roadside (accumulation subpopulation), Primary Logging Completion Year (PLC YR) and slope range was included to provide further opportunity to analysis the data.

Figure 2. Corresponding stump height data in Figure 1 shown in the '*TFL 47 Stump Height Analysis 2023-04-17*' spreadsheet.

TFL 47 Stump Height Analysis - Data ALL DATA = IMM & MAT

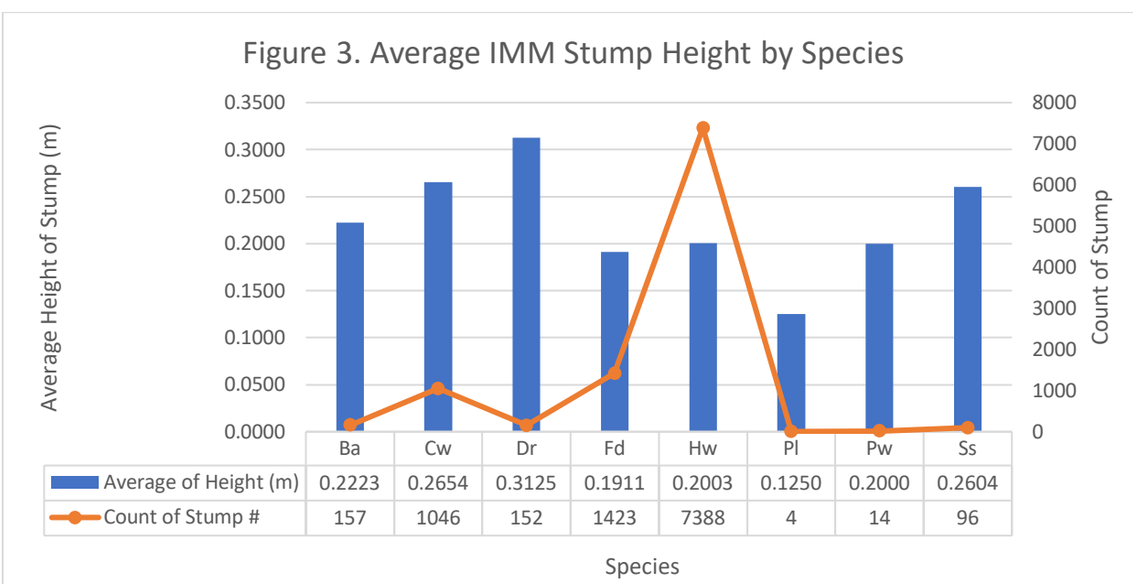
PLC YR	Block	Maturity	Plot	Slash or Roadside	Stump #	Species	Height (m)	Diameter (cm)	Falling Method	Slope (%)	Slope Range (%)	Comment
2022	6-91	IMM	SBX2	Slash	1	Hw	0.5	12	M	10	6-10	
2022	6-91	IMM	SBX2	Slash	2	Hw	0.1	28	M	10	6-10	
2022	6-91	IMM	SBX2	Slash	3	Hw	0.0	34	M	10	6-10	
2022	6-91	IMM	SBX2	Slash	4	Fd	0.1	60	M	10	6-10	
2022	6-91	IMM	SBX2	Slash	5	Hw	0.1	34	M	10	6-10	

In total, data was collected for 13,017 stumps. Of those, 12,562 stumps were in blocks classified as Immature (IMM) (**Table 1**) and 455 stumps were in blocks classified as Mature (MAT).

Table 1. Count of IMM stumps by Falling Method.

Maturity	Falling Method	Count of Stumps (#)
IMM	Hand (H)	2,193
IMM	Mechanical (M)	10,280
IMM	Uncut[2] (-)	89
	Total	**12,562**

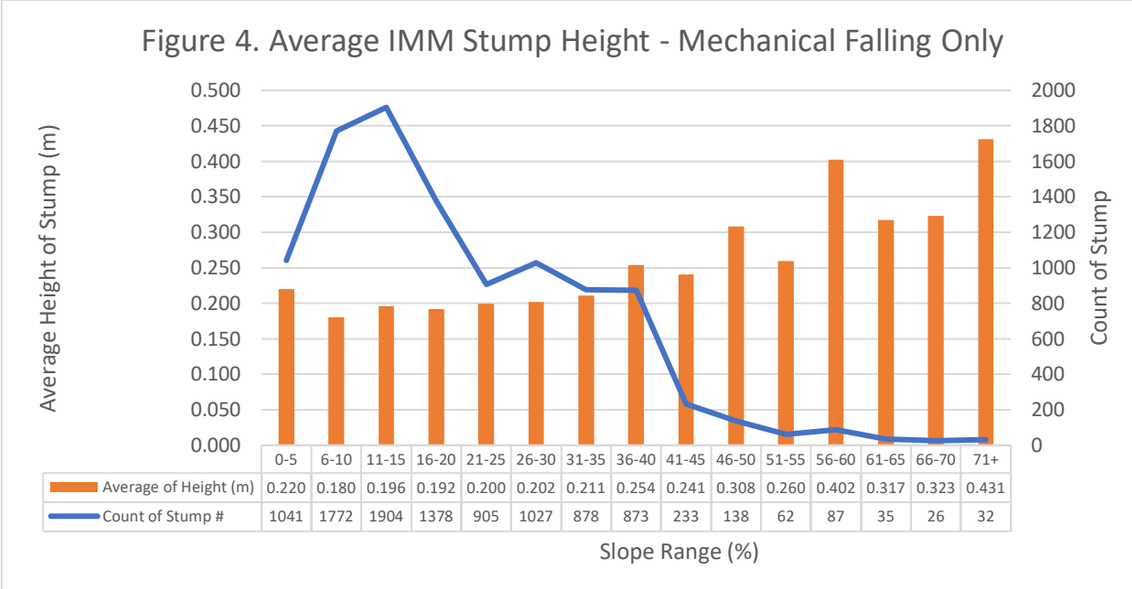
The majority of the IMM stump data was collected on Hw (71%), Fdc (14%) and Cw (10%). The rest of the species make up the remaining 5%. This is illustrated in **Figure 3**, along with the average IMM stump height (m). These results are consistent with the Harvest Billing System (HBS) 5-yr harvest volumes (%) by species as shown in the *Provincial Timber Management Goals, Objectives & Targets for TFL 47 (*September 12, 2022).



Specific to the mechanical falling method, the average IMM stump height across all slope ranges is 0.208 m and for slopes ≤40% the average is 0.203 m. **Figure 4** illustrates the average IMM stump height for slopes 0-71+%, broken down into 5% slope ranges.

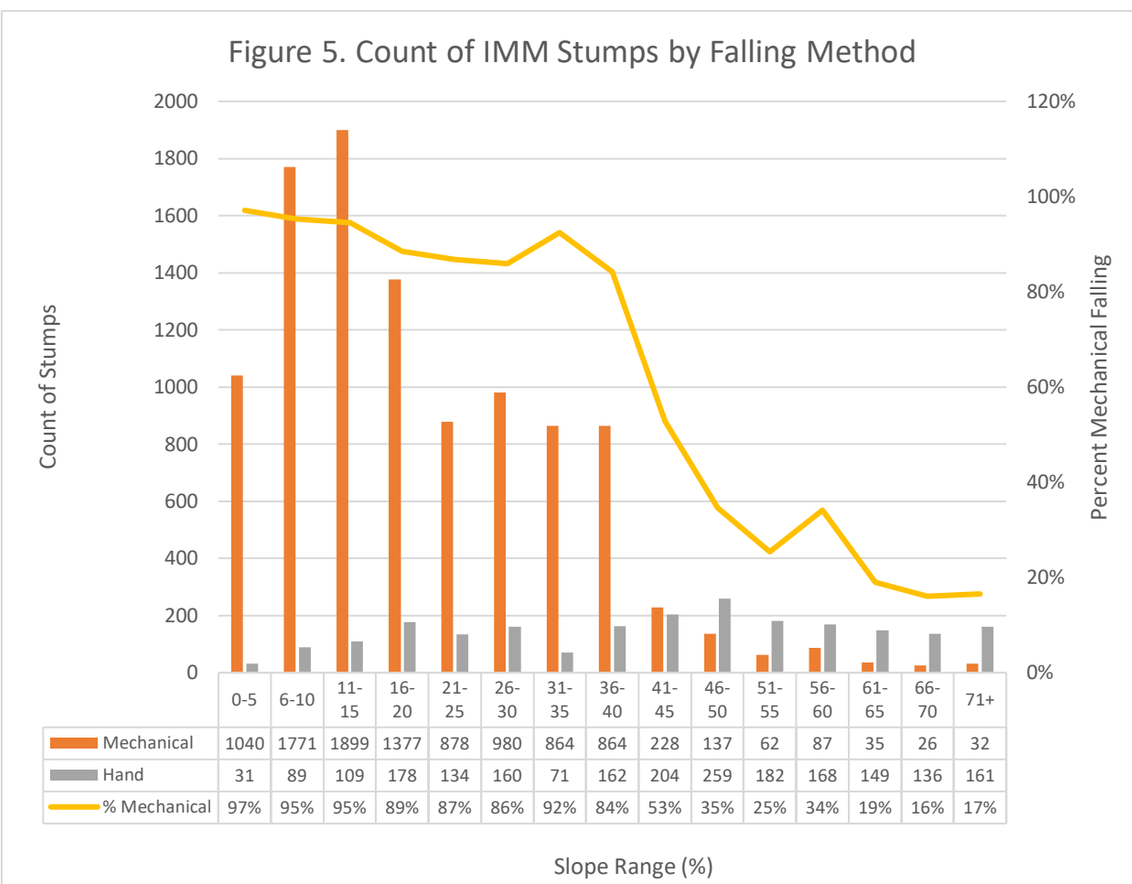
[1] https://www2.gov.bc.ca/gov/content/industry/forestry/competitive-forest-industry/timber-pricing/forest-residue-waste/provincial-logging-residue-and-waste-measurements-procedure-manual-coast

[2] Stumps that are still attached to the tree and are generally small diameter trees that were pushed over by the machine and left uncut (excluded from the analysis).



	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71+
Average of Height (m)	0.220	0.180	0.196	0.192	0.200	0.202	0.211	0.254	0.241	0.308	0.260	0.402	0.317	0.323	0.431
Count of Stump #	1041	1772	1904	1378	905	1027	878	873	233	138	62	87	35	26	32

Figure 5 shows that the proportion of mechanically felled IMM stumps, measured as a percentage of the total stumps, drops off significantly as slopes increase above 40%. Mechanical falling is the dominant falling method on stumps measured on slopes ≤40% in this data. Although the average IMM stump height across all slope categories is 0.208 m, slopes dominated by mechanical falling show an average stump height of 0.203 m.



	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71+
Mechanical	1040	1771	1899	1377	878	980	864	864	228	137	62	87	35	26	32
Hand	31	89	109	178	134	160	71	162	204	259	182	168	149	136	161
% Mechanical	97%	95%	95%	89%	87%	86%	92%	84%	53%	35%	25%	34%	19%	16%	17%

<u>Proposal</u>

The current Management Plan for TFL 47 uses a default stump height of 0.30 m. This was based primarily on the predominate historic use of hand-falling. However, based on the data collected, TimberWest is proposing to use an average stump height of 0.20 m in the base case for managed stands where the slope is ≤40%, as these slopes are dominated by mechanical falling.

Appendix B

Stand Level Retention Calculations

TFL 47 Management Plan 5

Stand Level Retention Summary - Blocks Harvested >= 2021

09-May-23

SMU	GBRO	TAUP (ha)	Gross Area (ha)	Required Internal Retention	Total Required Retention	Total Stand Level Retention from Site Plan	Grizzly	Goshawk	Red Listed	First Nations	Riparian	UWR	Karst	HVFH	Recreation	Foreshore	Inoperable	Non-Contributing	ESA	Terrain	Retention VQO	Blue Listed	Alienated	LRD with no Constraint Overlap	Constraint or LRD Co-located with Stand Retention	Total Stand Retention (RRZ or WTP)	Stand Retention Not in constrained or LRD	Target Retention not co-located in Constraint or LRD	Percent of SMU in Stand Retention	Percentage of Total Block Area (Gross or TAUP) in Retention but not in Constraint or LRD
5-024	Yes	17.03	13.49	-	2.02	2.29					2.29														2.29	2.29	-	0%	17%	
5-026	Yes	7.01	5.73	-	0.86	1.27	0.78				0.45													0.04	1.27	1.27	0.00	0%	22%	
5-027	Yes	12.28	9.17	-	1.38	2.48																		2.25	2.25	2.48	0.23	17%	27%	
5-036	Yes	13.41	10.16	-	1.52	2.46					2.09													0.36	2.46	2.46	0.00	0%	24%	
5-037	Yes	2.57	2.09	-	0.31	0.36					0.09													0.24	0.33	0.36	0.04	12%	17%	
5-098	Yes	10.59	8.36	-	1.25	1.41										0.68	0.69							0.00	1.38	1.41	0.03	3%	17%	
5-101F	Yes	13.34	11.44	-	1.72	1.89					0.52					0.66		0.01						0.64	1.83	1.89	0.06	4%	17%	
5-105E2	Yes	32.16	27.96	2.10	4.19	4.19	1.43				2.44													0.23	4.10	4.19	0.10	2%	15%	
5-110B	Yes	39.78	34.17	2.56	5.13	5.62					5.62														5.62	5.62	0.00	0%	16%	
5-112A	Yes	34.09	29.29	2.20	4.39	4.81												2.70						1.35	4.05	4.81	0.76	17%	16%	
5-113B	Yes	29.78	25.85	1.94	3.88	3.93	2.55				0.77														3.31	3.93	0.62	16%	15%	
5-114	Yes	6.32	5.24	-	0.79	0.88	0.01																0.46	0.21	0.68	0.88	0.19	25%	17%	
5-115B	Yes	16.77	13.77	-	2.07	2.21					1.81													0.33	2.14	2.21	0.06	3%	16%	
5-138	Yes	8.91	7.34	-	1.10	1.18																			-	1.18	1.18	100%	16%	
5-139	Yes	12.80	10.64	-	1.60	1.71					0.23														0.23	1.71	1.48	93%	16%	
5-141	Yes	17.70	14.51	-	2.18	2.41					2.17														2.17	2.41	0.24	11%	17%	
5-142	Yes	16.86	14.03	-	2.10	2.22	0.81				1.41													0.00	2.22	2.22	-	0%	16%	
5-198A	Yes	35.80	28.98	2.17	4.35	4.70					3.36													0.02	3.38	4.70	1.32	30%	16%	
5-199	Yes	23.89	19.89	1.49	2.98	3.19				0.53														1.40	1.93	3.19	1.27	42%	16%	
5-203	Yes	21.02	17.41	1.31	2.61	2.71	0.07																	0.02	0.09	2.71	2.62	100%	16%	
5-210	Yes	15.80	12.75	-	1.91	2.62					2.58													0.03	2.61	2.62	0.01	1%	21%	
5-350	Yes	3.73	3.25	-	0.49	0.47											0.47								0.47	0.47	0.00	0%	15%	
5-352	Yes	5.74	4.90	-	0.74	0.84											0.84								0.84	0.84	0.00	0%	17%	
5-354	Yes	24.20	20.72	1.55	3.11	3.48											3.48								3.48	3.48	-	0%	17%	
5-357	Yes	5.21	4.48	-	0.67	0.73											0.68							0.03	0.72	0.73	0.01	2%	16%	
5-358	Yes	14.90	12.92	-	1.94	1.98											0.55							1.43	1.98	1.98	0.00	0%	15%	
5-401	Yes	14.46	11.75	-	1.76	1.90					1.50														1.50	1.90	0.40	23%	16%	
5-60C	Yes	11.04	9.56	-	1.43	1.48					1.48														1.48	1.48	0.00	0%	15%	
6-107	Yes	24.41	21.16	1.59	3.17	3.25					3.25														3.25	3.25	0.00	0%	15%	
6-110	Yes	15.16	13.09	-	1.96	2.06								0.07		0.19								1.79	2.05	2.06	0.01	1%	16%	
6-117	Yes	33.55	28.44	2.13	4.27	5.12					2.94														2.94	5.12	2.18	51%	18%	
6-131	Yes	18.85	14.52	-	2.18	2.91					2.83													0.08	2.91	2.91	-	0%	20%	
6-133	Yes	10.96	9.35	-	1.40	1.62				0.47														0.85	1.32	1.62	0.29	21%	17%	
6-137	Yes	16.42	14.09	-	2.11	2.34										0.54								1.80	2.34	2.34	0.00	0%	17%	
6-139	Yes	7.75	6.66	-	1.00	1.09																			-	1.09	1.09	100%	16%	
6-144	Yes	8.65	7.44	-	1.12	1.21																			-	1.21	1.21	100%	16%	
6-163	Yes	10.41	8.97	-	1.35	1.44																			-	1.44	1.44	100%	16%	
6-165	Yes	9.77	8.13	-	1.22	1.32					0.63			0.52										0.11	1.25	1.32	0.06	5%	16%	
6-34C	Yes	6.42	5.52	-	0.83	0.90								0.10										0.78	0.88	0.90	0.02	2%	16%	
6-34D	Yes	11.66	10.06	-	1.51	1.60																			-	1.60	1.60	100%	16%	
6-42C	Yes	9.78	8.48	-	1.27	1.30					0.26			0.92										0.10	1.28	1.30	0.02	2%	15%	
6-42E	Yes	20.18	15.88	1.19	2.38	2.70					2.02									0.49				0.19	2.70	2.70	-	0%	17%	
6-42F	Yes	7.35	6.25	-	0.94	1.10																			-	1.10	1.10	100%	18%	
6-43	Yes	27.27	23.57	1.77	3.54	3.70										1.09	0.00							2.61	3.70	3.70	0.01	0%	16%	
6-44C	Yes	9.53	8.11	-	1.22	1.30										0.34	0.80							0.01	1.15	1.30	0.15	13%	16%	
6-74A	Yes	6.15	5.33	-	0.80	0.81		0.65																	0.65	0.81	0.17	21%	15%	
6-75C	Yes	27.16	23.36	1.75	3.50	3.80																		3.16	3.16	3.80	0.64	18%	16%	
6-76	Yes	48.32	41.08	3.08	6.16	6.20		5.27																	5.27	6.20	0.92	15%	15%	
6-801	Yes	9.42	8.12	-	1.22	1.31																		1.29	1.29	1.31	0.02	1%	16%	
6-802	Yes	11.36	9.76	-	1.46	1.60					1.39													0.19	1.58	1.60	0.02	1%	16%	
6-816	Yes	32.69	27.76	2.08	4.16	4.93					0.86							0.29							1.15	4.93	3.78	91%	18%	
6-83	Yes	32.58	28.27	2.12	4.24	4.30		3.05																1.25	4.30	4.30	-	0%	15%	
6-85A	Yes	13.34	11.52	-	1.73	1.83																1.11		0.72	1.83	1.83	-	0%	16%	
6-85C	Yes	6.93	6.02	-	0.90	0.91																			-	0.91	0.91	100%	15%	

SMU	GBRO	TAUP (ha)	Gross Area (ha)	Required Internal Retention	Total Required Retention	Total Stand Level Retention from Site Plan	Grizzly	Goshawk	Red Listed	First Nations	Riparian	UWR	Karst	HVFH	Recreation	Foreshore	Inoperable	Non-Contributing	ESA	Terrain	Retention VQO	Blue Listed	Alienated	LRD with no Constraint Overlap	Constraint or LRD Co-located with Stand Retention	Total Stand Retention (RRZ or WTP)	Stand Retention Not in constrained or LRD	Target Retention not co-located in Constraint or LRD	Percent of SMU in Stand Retention	Percentage of Total Block Area (Gross or TAUP) in Retention but not in Constraint or LRD
6-86	Yes	23.87	20.66	1.55	3.10	3.21			0.11									0.65						1.33	2.09	3.21	1.12	36%	16%	
6-89C	Yes	13.60	11.80	-	1.77	1.80																		1.80	1.80	1.80	-	0%	15%	
6-91	Yes	24.84	21.53	1.61	3.23	3.30												0.25						0.53	0.78	3.30	2.53	78%	15%	
6-92	Yes	31.33	26.79	2.01	4.02	4.54					2.15			0.08			0.78							0.03	3.03	4.54	1.51	37%	17%	
6-99A	Yes	10.18	8.74	-	1.31	1.43																		1.35	1.35	1.43	0.08	6%	16%	
9-021A	Yes	9.49	7.47	-	1.12	1.30																			-	1.30	1.30	100%	17%	
9-105	Yes	3.81	3.11	-	0.47	0.51																0.38		0.12	0.50	0.51	0.01	1%	16%	
9-106	Yes	7.63	6.05	-	0.91	1.01					0.66										0.00			0.00	0.66	1.01	0.35	38%	17%	
9-116	Yes	5.77	4.71	-	0.71	0.75			0.15		0.59								0.01					0.00	0.75	0.75	0.00	0%	16%	
9-117	Yes	12.56	9.96	-	1.49	1.70																			-	1.70	1.70	100%	17%	
9-129	Yes	51.07	39.95	3.00	5.99	6.30					6.02													0.28	6.30	6.30	0.01	0%	16%	
9-20A	Yes	12.41	9.95	-	1.49	1.76																0.02			0.02	1.76	1.75	100%	18%	
9-20B	Yes	38.01	32.02	2.40	4.80	5.99					1.05													3.20	4.25	5.99	1.74	36%	19%	
9-22A	Yes	14.05	11.33	-	1.70	1.91					0.88														0.88	1.91	1.03	61%	17%	
9-9C	Yes	10.16	7.48	-	1.12	1.36			0.16		0.45				0.21									0.12	0.95	1.36	0.41	36%	18%	
10-001	Yes	19.03	15.55	1.17	2.33	2.49					0.19													2.30	2.49	2.49	0.00	0%	16%	
10-011	Yes	2.45	1.80	-	0.27	0.40																			-	0.40	0.40	100%	22%	
TB001	Yes	0.27	0.27	-	0.04	-																			-	-	-	0%	0%	
GBR Total	**Yes**	**1,193.79**	**999.96**	**42.77**	**149.99**	**165.84**	**5.65**	**8.97**	**0.42**	**1.00**	**54.99**		**-**	**1.69**	**0.21**	**3.50**	**8.29**	**3.90**	**0.01**	**0.49**	**0.00**	**1.51**	**0.46**	**34.54**	**125.63**	165.84	**40.21**	**27%**	**17%**	**4.0%**
																										-				
12-002A	No	4.60	4.34	NA	0.32	0.27																			-	0.27	0.27	84%	6%	
12-002B	No	5.21	4.89	NA	0.36	0.32					0.16														0.16	0.32	0.17	47%	6%	
12-108A	No	12.14	11.20	NA	0.85	0.93					0.15														0.15	0.93	0.78	91%	8%	
12-201	No	5.18	3.89	NA	0.36	0.39																			-	0.39	0.39	100%	7%	
12-203	No	5.01	4.69	NA	0.35	0.32					0.04														0.04	0.32	0.28	80%	6%	
12-204	No	7.17	6.64	NA	0.50	0.53																			-	0.53	0.53	100%	7%	
12-514	No	4.56	4.27	NA	0.32	0.30									0.12										0.12	0.30	0.18	55%	7%	
12-77	No	3.87	3.61	NA	0.27	0.26																			-	0.26	0.26	94%	7%	
Quadra Total (Non-GBRO)	**No**	**47.74**	**43.53**	**NA**	**3.34**	**3.32**	**-**	**-**	**-**	**-**	**0.35**	**-**	**-**	**-**	**0.12**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.47**	**3.32**	**2.85**	**85%**	**7%**	**6.0%**
17-009	No	34.41	22.40	NA	2.41	2.39					1.79				0.27										2.06	2.39	0.32	13%	7%	
17-012	No	20.76	19.06	NA	1.45	1.69						0.30													0.30	1.69	1.39	96%	8%	
17-030	No	1.79	1.79	NA	0.13	-																			-	-	-	0%	0%	
17-063	No	46.04	42.54	NA	3.22	3.50														2.78					2.78	3.50	0.72	22%	8%	
17-064	No	30.16	27.16	NA	2.11	2.75											0.72								0.72	2.75	2.03	96%	9%	
17-105	No	22.34	20.33	NA	1.56	2.01																			-	2.01	2.01	100%	9%	
17-130	No	39.33	36.31	NA	2.75	3.03					2.87		0.14												3.01	3.03	0.02	1%	8%	
17-150	No	23.51	21.72	NA	1.65	1.69					1.52														1.52	1.69	0.18	11%	7%	
17-160	No	25.11	23.06	NA	1.76	1.96					1.59														1.59	1.96	0.37	21%	8%	
209-1A	No	7.64	7.05	NA	0.53	0.59																			-	0.59	0.59	100%	8%	
209-2	No	25.44	23.63	NA	1.78	1.81											1.41								1.41	1.81	0.39	22%	7%	
256-11	No	13.83	12.70	NA	0.97	1.12											1.12								1.12	1.12	0.00	0%	8%	
256-15	No	24.86	22.70	NA	1.74	2.16					1.68														1.68	2.16	0.48	28%	9%	
256-9	No	41.28	36.34	NA	2.89	2.94											2.94								2.94	2.94	0.00	0%	7%	
BC-5	No	18.79	17.35	NA	1.32	1.43					0.91														0.91	1.43	0.52	39%	8%	
Bonanza Total (Non-GBRO)	**No**	**375.29**	**334.14**	**NA**	**26.27**	**29.06**	**-**	**-**	**-**	**-**	**10.35**	**0.30**	**0.14**	**-**	**0.27**	**-**	**6.20**	**-**	**-**	**2.78**	**-**	**-**	**-**	**-**	**20.04**	**29.06**	**9.02**	**34%**	**8%**	**2.4%**
Total Combined Non-GBRO	**No**	**423.03**	**377.67**	**NA**	**29.61**	**32.38**	**-**	**-**	**-**	**-**	**10.70**	**0.30**	**0.14**	**-**	**0.39**	**-**	**6.20**	**-**	**-**	**2.78**	**-**	**-**	**-**	**-**	**20.51**	**32.38**	**11.87**	**40%**	**8%**	**2.8%**

Notes:

Reporting for Blocks harvested >= 2021

Gross Harvest Area = Net Area to Restock + Unnatural Non-Productive (roads).

GBRO uses Gross Area to determine the retention % required (15%)

Total Area Under Plan (TAUP) = Standard Units + Retention + Non-Productive

Non-GBRO uses TAUP to determine the retention % required (7%).

Appendix C

VRI Phase II Adjustment

Tree Farm Licence 47
Vegetation Resources Inventory

Statistical Adjustment

Version 1.0

PREPARED BY:

TECO NATURAL RESOURCE GROUP LTD.

September 2010

naturally resourceful.

TECO Natural Resource Group Limited
carbon community ecology energy forest land technology

EXECUTIVE SUMMARY

TimberWest Forest Corp. (TimberWest) initiated a Vegetation Resources Inventory (VRI) program for Tree Farm License (TFL) 47 in 2006 to upgrade and adjust their existing inventory. The VRI Phase I was completed in March 2007 using 2006 1:15,000 aerial photos. The VRI Phase II project implementation plan (VPIP)[1] was prepared in 2007, with ground sampling carried out in 2007, 2008 and 2010. NVAF sampling was completed in March 2010. An adjustment of the Phase I was completed in 2010 using VDYP7. The objective of this project was to use the information from the VRI Phase II plots to adjust the inventory in preparation for timber supply review.

Height, age, basal area, stems per hectare, Lorey height and total live net merchantable volume were adjusted following Ministry of Forests and Range (MFR) VRI adjustment methods. The target population for the VRI Phase II was defined as all TFL 47 vegetated treed polygons where the main layer is treed and greater than 30 years of age (88,278 ha). The target population was stratified by leading species and age into the following four strata:

1. Hemlock[2] 30-100 years
2. Hemlock 100 + years
3. All other species 30-100 years
4. All other species 100 + years

After adjustment, **height and Lorey height were unchanged**. **Age, SPH and basal area increased by 39%, 114% and 31%** respectively. The increase in age resulted in a **16% decrease in site index**. The initial average Phase I **net merchantable volume** (12.5 cm+) was 389 m^3/ha. The attributed adjusted net merchantable volume estimate was 498 m^3/ha, **a 28% increase**. Following the Phase II adjustment the final net merchantable volume estimate was 512 m^3/ha, a **3% increase** over the attribute adjusted Phase I estimate and a **32% increase** over the unadjusted Phase I estimate. The sampling error for the volume adjustment was ±11% (95% probability).

A main source of uncertainty with this analysis is in the SPH estimations. Phase I SPH was under-estimated by approximately 114% with a sampling error of ±21% (95% probability). It is likely that this under-estimation is related to the layer estimate of SPH used for comparison. Phase II estimates will include all trees measured within the plot, and may include trees from intermediate or suppressed tree layers.

The recommendations from this project are:

1. TimberWest use the adjusted estimates of height, age, basal area, stems per hectare, and volume in the timber supply analysis base case.
2. TimberWest consider the forest health statistics provided in this report as a starting point for investigating specific forest health issues.
3. TimberWest use the adjusted inventory for forest management planning.
4. TimberWest explore other non-standard adjustment methods (e.g. regression) for attributes that showed a significant trend.

---

[1] Timberline Natural Resource Group Ltd. 2007. *TimberWest Forest Corp. Tree Farm License 47 Vegetation Resources Inventory Phase II Project Implementation Plan.* Unpublished Report, July 2007, amended February 15, 2008 and October 29, 2009. 28 pp.

[2] Hemlock includes both western hemlock and mountain hemlock.

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1.0 INTRODUCTION

1.1 Vegetation Resources Inventory Overview

The Vegetation Resources Inventory (VRI) is the Ministry of Forests and Range's (MFR) forest inventory standard on public lands in BC. Where possible, forest licensees must use the VRI standard in their Data Package submission for Timber Supply Review (TSR).

The VRI is a four-step process (Figure 1):

1. Phase I (unadjusted inventory data) – Estimates of polygon attributes are derived for the target population, usually from photo-interpretation.
2. Phase II (ground sample data) – Measurements are taken from randomly located ground samples in the target population.
3. Net Volume Adjustment Factor (NVAF) sampling – Random trees are selected for stem-analysis from the Phase II samples to develop adjustment ratios that correct taper and decay estimation bias.
4. Statistical Adjustment Phase – The Phase I estimates are adjusted using the NVAF-corrected Phase II ground samples to provide an adjusted unbiased estimate of forest inventory attributes. The final product is an adjusted VRI database.

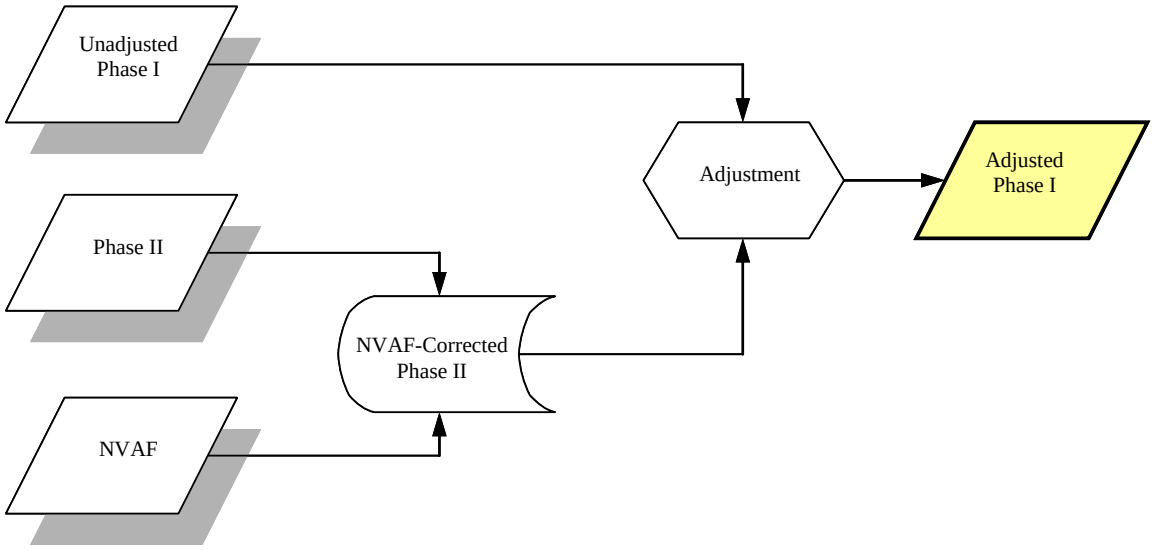

Figure 1. VRI Flow-chart.

1.2 TFL 47 VRI Program

TimberWest Forest Corp. (TimberWest) completed a VRI Phase I Strategic Inventory Plan[3] covering the Bonanza and Johnstone Strait Management Units of TFL 47 in 2006. Timberline Natural Resources Group Ltd. (Timberline) prepared a Phase II Vegetation Resources Inventory (VRI) Project Implementation Plan (VPIP)[1] to document the 2007 sample design and implementation of the ground program.

The sampling objective of the Phase II program is to estimate the net merchantable volume in the target population with a sampling error of ±10% (95% confidence interval). Mecredy Cruising & Forest Consulting Ltd. (Mecredy) completed the field work in November 2007 and November 2008. The initial intent of the field program was to establish 60 samples (including all of the Net Volume Adjustment Factor [NVAF] enhancement plots).

Timberline completed a preliminary analysis in March, 2009, and the resulting sampling error did not achieve the target with 60 plots. In order to maintain cost efficiency, the target sampling error was modified to ±25% (95% confidence interval) for the estimate of net merchantable volume in three of the four strata[4]. The modified objective required an additional 9 samples to be established (which were established by Mecredy in 2010). A second preliminary analysis was completed by Timberline in March 2010.[5]

The NVAF destructive sampling was completed by Azmeth Forest Consultants in March 2010. This report documents the development of the NVAF ratios and their application in the final adjustment.

1.3 Project Objective

The TFL 47 Phase I inventory is based on photo-interpreted inventory attribute estimates using the current VRI procedures. The Provincial Chief Forester requires that the bias implicit in photo-interpretation be removed and the statistical precision of the inventory be known before the Annual Allowable Cut (AAC) is determined. The VRI is designed to provide the Chief Forester with a level of comfort in the inventory for TSR.

The project objective is to:

> *Upgrade and adjust the TFL 47 VRI Phase I forest inventory to MFR standards in preparation for the next Timber Supply Review.*

Forest management issues on TFL 47 that will benefit from an adjusted VRI inventory include:

1. *Timber supply analysis – will help to remove uncertainty in timber supply analysis projections.*

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[3] TimberWest Forest Corp. 2006. *TFL 47 Bonanza Lake and Johnstone Straits Management Units VRI Strategic Inventory Plan*. Prepared by Warren Nimchuk, RPF and Doug Reeve, RFT, on behalf of TimberWest Forest Corp.

[4] The three strata of interest include: H ≤ 100yrs, H > 100yrs & Other ≤ 100yrs. The Other > 100yrs stratum had high variability, and would have required an additional 28 plots to reach the target sampling error.

[5] Timberline Natural Resource Group. 2010. TFL 47 VRI preliminary adjustment 2 memo prepared for Timberwest Forest Corp.

2. *Operability mapping – will provide additional information to confirm distribution of merchantable timber. Better age and height data may also improve the identification and classification of problem forest types, sites with low growing potential, and deciduous stands.*
3. *Biodiversity – may aid in delineating wildlife tree patches, deer winter range, and seral stages.*
4. *Land use planning – will help identify areas of specific interest for the 'Central Coast Land Resource Management Plan', and 'Vancouver Island Land Use Plan'.*

1.4 Analysis and Reporting Objectives

The 2010 analysis objectives were to:

1. *Compile the 2006/2007/2010 VRI Phase II (ground data) to MFR standards;*
2. *Compute the NVAF ratios; and*
3. *Complete a statistical adjustment of the inventory using the most recent MFR standards.*[6]

The report objective is to:

1. *Document the statistical adjustment procedures used in this analysis;*
2. *Report on the results and make recommendations; and*
3. *Identify areas of uncertainty in the data.*

1.5 Terms of Reference

This final report for the TFL 47 VRI statistical adjustment was prepared for Timberwest and the MFR, Forest Analysis and Inventory Branch. Debora Soutar, *RPF*, of Madrone Environmental Services Ltd. was the Forest Investment Account (FIA) coordinator. Hugh Carter, *MSc, RFT*, (Timberline) was the project manager and provided technical support. Eleanor McWilliams, *RPF* and Stephanie Ewen, *RPF* completed the analysis and prepared the final report. The results from this report will be reviewed and approved by the MFR Forest Analysis and Inventory Branch (FAIB) prior to use in TSR.

[6] Ministry of Forests and Range, 2008. *Vegetation Resources Inventory Interim Procedures and Standards for Statistical Adjustment of Baseline VRI Timber Attributes*. Unpublished Report, January 2008. 36 p.

2.0 DATA

2.1 Land Base

TFL 47 comprises two[7] management units (MU) located on northern Vancouver Island near Port McNeill (Bonanza Lake MU) and parts of the coastal mainland and islands in the Johnstone Strait (Johnstone Strait MU) (Figure 2). The total TFL area is 123,034 ha. The total vegetated treed area of the TFL is 110,118 ha.

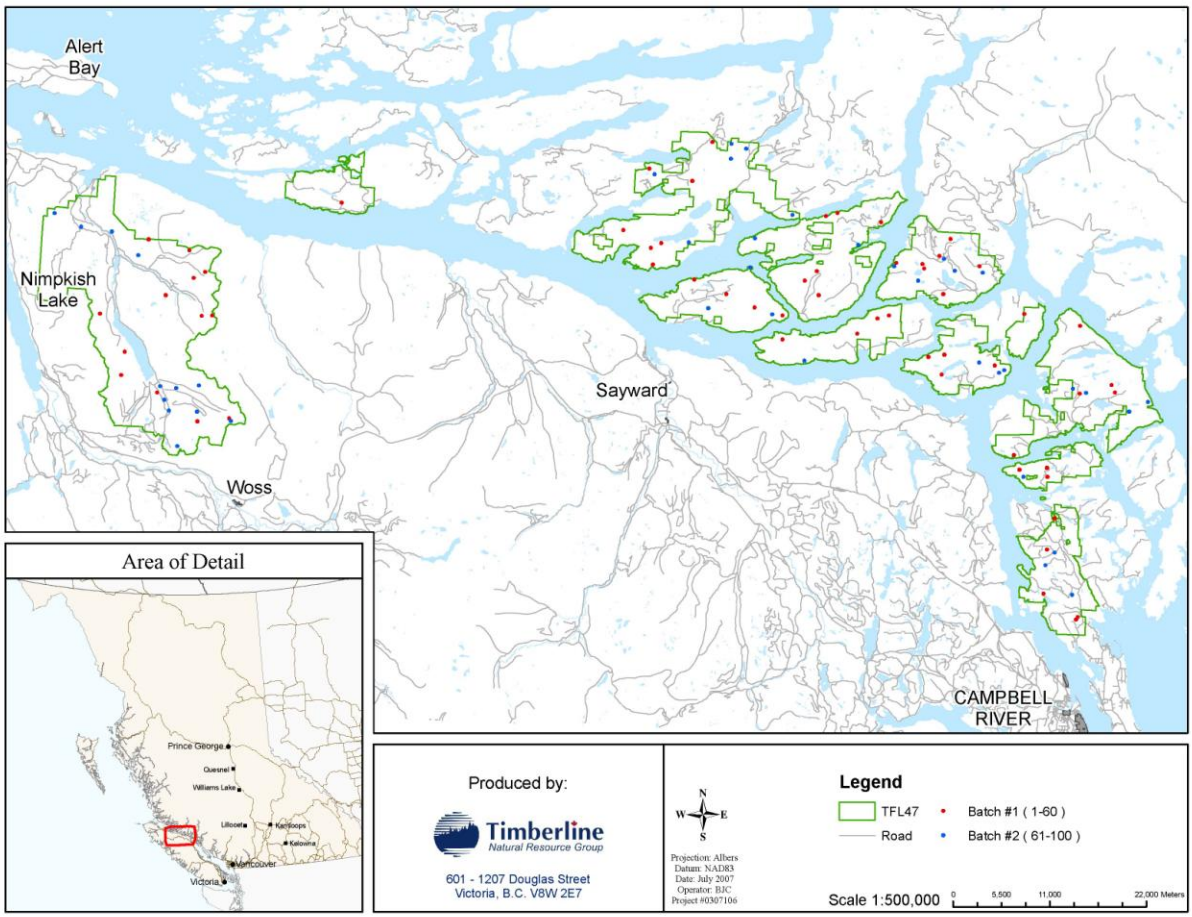

Figure 2. Geographic location of TFL 47, including sample locations (batch 1 and batch 2).

TFL 47 is located in the Coastal Western Hemlock (CWH) and Mountain Hemlock (MH) biogeoclimatic zones (Figure 3). The dominant species in both management units is western hemlock (Hw) comprising on average 63% of the area, followed (in decreasing area proportion) by Douglas-fir (Fdc), western redcedar (Cw), yellow cedar (Yc) mountain hemlock (Hm), and other species (Table 1 and Table 2). The majority (68%) of the area is in younger stands (< 80 years old) with 24% occurring in mature stands (>120 years old).

[7] A third unit (Moresby Island MU) is no longer part of TFL 47.

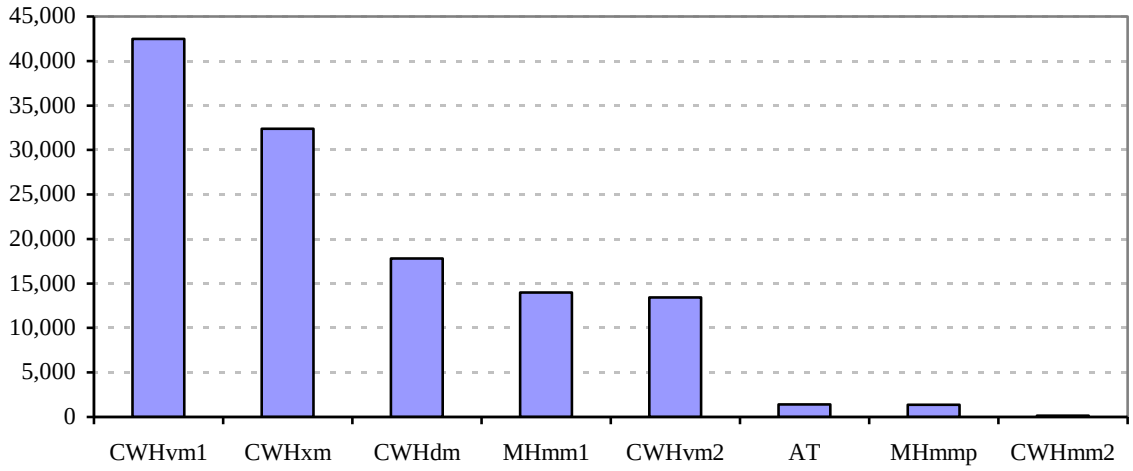

Figure 3. TFL 47 BGC subzone area distribution.

Table 1. TFL 47 species and age class distribution – Bonanza Management Unit.

Leading Species	MoFR Age Class									Total	
	1	2	3	4	5	6	7	8	9	***Ha***	**%**
BA	361	48	32	49	16		24	683	1,515	*2,727*	8%
CW	161	108	59				18	39	136	*520*	2%
DR	8	141	83						12	*245*	1%
FDC	723	1,324	14			4				*2,064*	6%
HM	104		14		21			1,002	2,641	*3,782*	12%
HW	5,608	5,713	2,131	582	95	47	25	896	3,266	*18,362*	56%
SS	24	127	64	6		5			13	*240*	1%
YC	232	9				5	19	2,178	2,390	*4,834*	15%
Total	*7,220*	*7,470*	*2,396*	*638*	*132*	*61*	*87*	*4,798*	*9,973*	*32,773*	100%
Total %	*22%*	*23%*	*7%*	*2%*	*0%*	*0%*	*0%*	*15%*	*30%*	*100%*	

Table 2. TFL 47 species and age class distribution – Johnstone Strait Management Unit.

Leading Species	MoFR Age Class									Total	
	1	2	3	4	5	6	7	8	9	***Ha***	**%**
BA	96	42						10	47	195	0%
BG	27		4							31	0%
CW	756	671	271	726	366	198	34	1,881	854	5,757	7%
DR	184	905	1,418	920	12					3,440	4%
FDC	1,978	2,655	756	5,501	2,211	725	39	978	176	15,017	19%
HM								172	119	291	0%
HW	7,769	9,772	7,159	14,768	3,500	886	316	4,619	2,002	50,790	66%
PL	4	128	129	766	303	11		9		1,349	2%
SS						16	4			20	0%
VB	213									213	0%
YC								296	16	312	0%
Total	*11,026*	*14,172*	*9,737*	*22,681*	*6,392*	*1,836*	*392*	*7,965*	*3,213*	*77,414*	100%
Total %	*14%*	*18%*	*13%*	*29%*	*8%*	*2%*	*1%*	*10%*	*4%*	*100%*	

All spatial GIS coverages used to define the TFL 47 landbase were obtained from TimberWest and Madrone staff (Table 3).

Table 3. TFL 47 Source coverages used in this project.

Coverage Name	Description	Date Received
TFL47.SHP	TFL 47 boundary coverage of Bonanza and Johnstone Strait MU's. Received as shape file from Ken Price, TimberWest.	2007-June-15
TFL47_DEPLETIONS06.SHP	Harvest depletions coverage occurring in 2006. Received from Ken Price, TimberWest.	2007-June-15
TEM_SUBZ.SHP	BGC subzone/variant linework, originating from the TFL 47 TEM coverage. Created by Ken Price, TimberWest.	2007-June-15
VRI.E00	VRI Phase I inventory of Bonanza and Johnstone Strait MU's. Originally created by IRC, March 31, 2007, and forwarded by Debora Soutar, Madrone. Note, this coverage has not yet gone through any data translation / conversion routines by the MoFR.	2007-June-05
	TFL 47 2006 1:15,000 air photo flight lines.	2007-June-05
Depletion2006_2010.shp	Depletion for areas harvested between 2006 and 2010. Received from Ken Price, TimberWest	2010-February-12

2.2 Target Population

The target population for the VRI Phase II was defined as all TFL 47 vegetated treed[8] (VT) polygons where the main layer is treed and greater than 30 years of age.[9] The main layer was

[8] Discussions with B.Storry, TimberWest that the majority of the forested landbase was operable, helped to confirm that the entire VT portion should be included in the target population (email corresp 21 June, 2007).

defined as the layer with the largest crown closure, and a layer was considered treed if the leading species was present with a minimum crown closure of 10%. The total area of the target population was 88,278 ha (Table 4; 72% of the total landbase or 80% of the VT landbase). All harvest depletions since the 2006 Phase I inventory mapping (up to January 1, 2010) were updated into the inventory.

Table 4. TFL 47 Phase II target population net down.

	Area removed (ha)	Area remaining (ha)	% of total	% of VT
Total Inventoried Area in 2006		126,654		
Area inside TFL in 2007	3,111	123,543		
Inventoried Area inside TFL in 2007	508	**123,034**	100%	
Vegetated Treed	12,847	110,188	90%	100%
Stands >30 years old	21,910	**88,278**	72%	80%
Bonanza MU	0	**24,559**	20%	22%
Johnstone Strait MU	0	**63,719**	52%	58%

2.3 Stratification

2.3.1 Ground Sampling

The target population was stratified by age and species using two age groups (30-100 years vs. 101+ years) and two species groups (Hw+Hm, vs. all others). This stratification also reflects the two different MUs since Johnstone Strait is mainly composed of second-growth stands while Bonanza includes a larger component of mature stands.

While the leading species is dominated by Hw, both Hw and Hm were combined into one species group for consistency, separated from all other species. Each stratum was further sub-stratified into volume[10] classes (<=400m^3/ha, and >400m^3/ha) to ensure appropriate distribution of the ground samples across the range of possible values (Table 5).[11]

[9] Stand age definition criteria were based on the 2007 projected year.

[10] Polygon specific net merchantable volume estimates were generated with Batch VDYP ver. 6, at 17.5cm DBH utilization limit. Note, stocking class codes were not provided in the VRI Phase I inventory. Therefore, stocking class codes were estimated at 0 for VT stands 0-120 years old, and 1 for VT stands >120 years old. Age, height and volume were projected to 2007.

[11] While the Bonanza and Johnstone Strait MU's have somewhat different stand characteristics, we chose not to separate the two as part of the stratification. The main reason is that the Johnstone Strait MU is much larger than the Bonanza, plus the MU differences are already largely addressed in the proposed stratification criteria.

Table 5. Stratum and sub-stratum area distribution within the target population.

Sub-stratum Area (ha)	Stratum Area (ha)				
	H ≤ 100yrs	Other ≤ 100yrs	H > 100yrs	Other > 100yrs	Total (ha)
Low volume (<= 400m^3/ha)	21,107	11,270	5,048	6,596	44,021
High volume (> 400m^3/ha)	19,536	6,025	12,015	6,681	44,257
Total	*40,643*	*17,295*	*17,063*	*13,277*	*88,278*

2.3.2 NVAF

An assessment of the merchantable volume by species was completed using all established Phase II samples. The species groupings and sample sizes were determined and five (5) NVAF strata were defined as follows:

1. Dead
2. Immature
3. Mature – H
4. Mature – B
5. Mature – C

Due to funding constraints, only partial funding was available for NVAF sampling. In consultation with the MFR Volume and Decay Officer a batched approach was implemented for the sample selection. Three batches for sampling were determined as follows:

1. Batch 1 – 41 trees
2. Batch 2 – 20 trees
3. Batch 3 – 39 trees

Due to financial constraints, only Batch 1 has been collected to date (Appendix III).

Table 6. NVAF sample distribution.

Stratum	Species	Total Merch Volume		Number of trees	
		% Total	% Group	Total	% Group
Dead	H	32	32	1	30
	Cw	24	24	2	20
	Other	44	44	5	50
	Total	***100***	***100***	***10***	***100***
Immature	H	28	47	21	47
	Fd	17	29	13	29
	Cw	11	18	8	18
	Other	3	6	3	6
	Total	***59***	***100***	***45***	***100***
Mature – H	H	19	47	20	44
	Sub-Total	***19***	***47***	***20***	***44***
Mature – B	B	*11*	*26*	*11*	*24*
	Fd	*3*	*8*	*4*	*9*
	S	*0*	*0*	*0*	*0*
	P	*0*	*0*	*0*	*0*
	Sub-Total	***14***	***34***	***15***	***33***
Mature – C	Cw	*4*	*9*	*5*	*11*
	Yc	*4*	*9*	*5*	*11*
	Sub-Total	***8***	***18***	***10***	***22***
	Total	***41***	***100***	***45***	***100***
Grand Total		***100***	***100***	***100***	***100***

2.4 Phase I Data

In 2006 TimberWest completed a VRI Phase I Strategic Inventory Plan[3] covering the Bonanza and Johnstone Strait MU's. Subsequently, Inventory Resources Co-operative (IRC) completed the TFL 47 Phase I inventory on March 31, 2007 using 2006 1:15,000 aerial photos (Table 7).

Table 7. TFL 47 photo-interpreted inventory statistics.

Stratum	Area (ha)	Height (m)	Lorey Height (m)	Age (yrs)	BA 7.5cm+ (m^2/ha)	SPH 7.5cm+ (trees/ha)	SI (m)	Vol. 12.5cm+ (m^3/ha)	Vol. 17.5cm+ (m^3/ha)
H ≤ 100yrs	40,643	26.6	24.6	59	48.2	743	26.3	409.2	401.3
Other ≤ 100yrs	17,295	26.0	23.6	64	41.0	547	25.1	334.4	329.1
H > 100yrs	17,063	33.1	28.7	242	52.0	416	14.0	443.1	441.6
Other > 100yrs	13,277	28.6	26.2	229	40.6	363	14.6	325.6	323.7
Total	*88,278*	*28.0*	*25.4*	*121*	*46.4*	*584*	*21.9*	*388.5*	*383.3*

2.5 Phase II (Ground Sampling)

2.5.1 Actual Sample Size

In the 2007 Phase II VPIP, one-hundred (100) plots were selected and split into two batches. Batch one included sixty (60) samples while batch two included forty (40) samples. Upon completion of an interim analysis[12] of the batch one data, Timberline recommended that TimberWest concentrate further sampling in the H > 100 yrs and Other ≤ 100 yrs strata to bring the sampling error down to ±25% as these were seen as the most important strata for future TSR. To achieve this objective nine new samples were established: five (5) in the H > 100 yrs stratum, and four (4) in the Other ≤ 100 yrs stratum. The nine additional samples were chosen from the existing batch 2 sample list and were the next five and four samples in the list for the H > 100 yrs and Other ≤ 100 yrs strata respectively (Table 8). Therefore a total of sixty-nine (69) samples were visited in the Phase II sampling (Appendix I). Six samples were identified as being inaccessible, and were replaced with sample locations in similar stand types according to standard plot-replacement protocol. Sample 45 was harvested and was replaced with sample 97. All remaining samples were measured with no occurrences of logged or unsafe samples.

[12] Timberline, April 2009. *Memo – TFL 47 Preliminary Analysis April 8, 2009*. Unpublished. p. 15.

Table 8. Sample size distribution by stratum and sub-stratum.

Stratum	Sub-Stratum	Area (ha)	(%)	Batch 1 Sample Size	Batch 2 Sample Size	Total Sample Size	(%)	Ha/ Plot
H ≤ 100yrs	High_vol	19,536	22%	13	0	13	19%	1,503
	Low_vol	21,107	24%	11	0	11	16%	1,919
	Total	***40,643***	46%	***24***	***0***	24	35%	***1,693***
Other ≤ 100yrs	High_vol	6,025	7%	6	0	6	9%	1,004
	Low_vol	11,270	13%	6	4	10	14%	1,127
	Total	***17,295***	20%	***12***	***4***	16	23%	***1,081***
H > 100yrs	High_vol	12,015	14%	9	4	13	19%	924
	Low_vol	5,048	6%	5	1	6	9%	841
	Total	***17,063***	19%	***14***	***5***	19	28%	***898***
Other > 100yrs	High_vol	6,681	8%	5	0	5	7%	1,336
	Low_vol	6,596	7%	5	0	5	7%	1,319
	Total	***13,277***	15%	***10***	***0***	10	14%	***1,328***
Total		***88,278***	***100%***	***60***	***9***	***69***	***100%***	***1,279***

2.5.2 Sampling Weights

Plot weights were computed based on the distribution of the sample size within sub-strata, using 69 plots (Table 9). Sampling weights ranged from 841 ha to 1,919 ha. In general, plots are evenly distributed amongst the sub-strata, as each are of equal importance in timber supply. The average weight was 1,279 ha/plot. The sampling weight for each individual ground sample is provided in Appendix I.

Table 9. Phase II Sampling weights.

Stratum	Sub-Stratum	Area (ha)	No. Plots	Area/ Plot
H ≤ 100yrs	High_vol	19,536	13	1,503
	Low_vol	21,107	11	1,919
Other ≤ 100yrs	High_vol	6,025	6	1,004
	Low_vol	11,270	10	1,127
H > 100yrs	High_vol	12,015	13	924
	Low_vol	5,048	6	841
Other > 100yrs	High_vol	6,681	5	1,336
	Low_vol	6,596	5	1,319

2.5.3 Phase II Plot Statistics

The Phase II average plot statistics are provided in Table 10. Phase I and Phase II data is provided in Appendix II.

Table 10. Phase II plot statistics.

Stratum	n	Height (m)	Age (yrs)	BA (m^2/ha)	SPH (trees/ha)	SI (m)	Lorey Ht. (m)	Live Vol. 12.5+ cm (m^3/ha)	Live Vol. 17.5+ cm (m^3/ha)
H ≤ 100yrs	24	25.6	73	59.9	1,620	24.3	22.5	468.7	436.3
Other ≤ 100yrs	16	25.7	99	49.4	986	24.9	25.3	409.7	385.1
H > 100yrs	19	30.4	462	77.3	845	14.0	27.5	673.8	666.2
Other > 100yrs	10	33.7	346	73.7	783	16.5	30.0	760.3	757.3
Total	*69*	*27.7*	*191*	*63.3*	*1,220*	*21.4*	*25.1*	*540.6*	*519.0*

Note: Phase II (ground sampling) volume was whole-stem volume less tops, stumps, NVAF-corrected cruiser-called decay, waste, and breakage.

2.6 NVAF Data

The NVAF sampling program was completed in March 2010. Forty-one (41) trees were selected (39 live and 2 dead trees) (Table 11, Appendix III). All ratios were calculated by Timberline and approved by the MFR Volume and Decay Sampling Officer (September 2010). After the initial analysis the MFR Volume and Decay Sampling Officer asked that the original three Mature strata (Mature C, Mature H, Mature B) be combined into a single Mature stratum. Table 11 provides a summary of the cruiser called Phase II volumes for conifer trees compared to the destructively sampled volumes as supplied by the MFR. On average, the Phase II tree volumes were very close to the NVAF volumes. The complete NVAF sample tree list is provided in Appendix III.

Table 11. NVAF tree summary statistics.

Live/ Dead	Maturity Class	Spp	No. Trees	Avg. Volume (m^3)		
				Phase II	NVAF	% Diff.
Live	Immature	All	18	1.317	1.378	4.68%
	Mature	All	21	3.288	3.290	0.06%
Dead	All	All	2	1.426	0.739	-48.18%
All	*All*	*All*	*41*	*2.332*	*2.326*	*-0.23%*

3.0 METHODS

3.1 Phase I Projection

Photo-interpretation was done using photos taken in 2006. For this analysis the photo-interpreted age was projected to 2008 by adding the required number of years.[13] The photo-interpreted height, BA, SPH, and corresponding net merchantable volume were also projected to 2008 using VDYP7 (version 7.5c.27). The model did not project BA, SPH, or volume where heights were less than 7.6m so these polygons were assumed to have no volume, BA, or SPH. All other critical VDYP7 inputs (species composition, crown closure, forest inventory zone, inventory standard, and BGC) were not modified.

3.2 NVAF

The NVAF ratios were generated by Timberline in September 2010 and approved by the MFR Volume and Decay Officer. Ratios were computed using the model-based method and applied to the Phase II net merchantable volume computed from the raw data.

3.3 Phase II Compilation

Timberline completed a preliminary compilation of Phase II data in March, 2009, and the resulting sampling error did not achieve the target with 60 plots. In order to maintain cost efficiency, the target sampling error was modified to ±25% (95% confidence interval) for the estimate of net merchantable volume in three of the four strata[14]. The modified objective required an additional 9 samples to be established (which were established by Mecredy in 2010). All 69 samples were used to complete this final analysis.

The standard five-point cluster was used in all stands. Height and net factors were used for all trees when available. Phase II net merchantable volume was the whole-stem volume less tops, stumps, cruiser-called decay, waste, and breakage. The Phase II data was NVAF adjusted. Volume was compiled to 12.5cm+ and 17.5cm+ for all strata.

The field-collected GPS points were analyzed to confirm that plots landed at the intended points. In all cases, the GPS point for the plot was within the polygon that the sample was intended to be located in. In all cases the intended polygon was used for analysis.

3.4 Statistical Adjustment

The most recent MFR VRI statistical adjustment standards were used to adjust height, age, BA (7.5+ cm), SPH (7.5+ cm), Lorey height (12.5+ cm) and live net merchantable volume (12.5+

[13] The original 60 Phase II plots were sampled in 2008. As per MFR standards the data is projected to the year that the majority of sampling was completed.

[14] The three strata of interest include: H ≤ 100yrs, H > 100yrs & Other ≤ 100yrs. The Other > 100yrs stratum had high variability, and would have required an additional 28 plots to reach the target sampling error.

cm).[15] The MFR adjustment procedures assume that the unadjusted (Phase I) inventory volume is biased due to two sources of error:

1. An attribute bias associated with the photo-interpreted height, age, BA, and SPH; and
2. A model bias inherent to the growth and yield model used to estimate volume (VDYP7).

Three critical attributes needed for volume prediction are not adjusted in the process but are important for determination of other critical attributes. The "inventory standard" attribute determines how basal area and stems per hectare are either used or generated, BGC zones are important for estimating volume loss and are needed for every polygon, and species composition is used to distribute the volume. Leaving species composition unadjusted is assumed to create a negligible bias.

The interim attribute adjustment procedure is a two-step process (Figure 4) described as follows:

- Step 1: Phase I height, age, basal area (7.5cm+), and stems per hectare (7.5cm+) bias are corrected using an adjustment ratio of means (ROM) calculated from the Phase I and Phase II plots. An attribute-adjusted volume is then estimated using VDYP7 with the adjusted height and age.
- Step 2: An adjustment ratio estimated from the attribute-adjusted volume (12.5cm+) and the NVAF-corrected Phase II volume is calculated and this ratio is used to correct the model bias in the attribute-adjusted volume.
- Step 2b: An adjustment ratio estimated from the attribute-adjusted Lorey height (12.5cm+) and the Phase II Lorey height is calculated and this ratio is used to correct the model bias in the attribute-adjusted Lorey height.

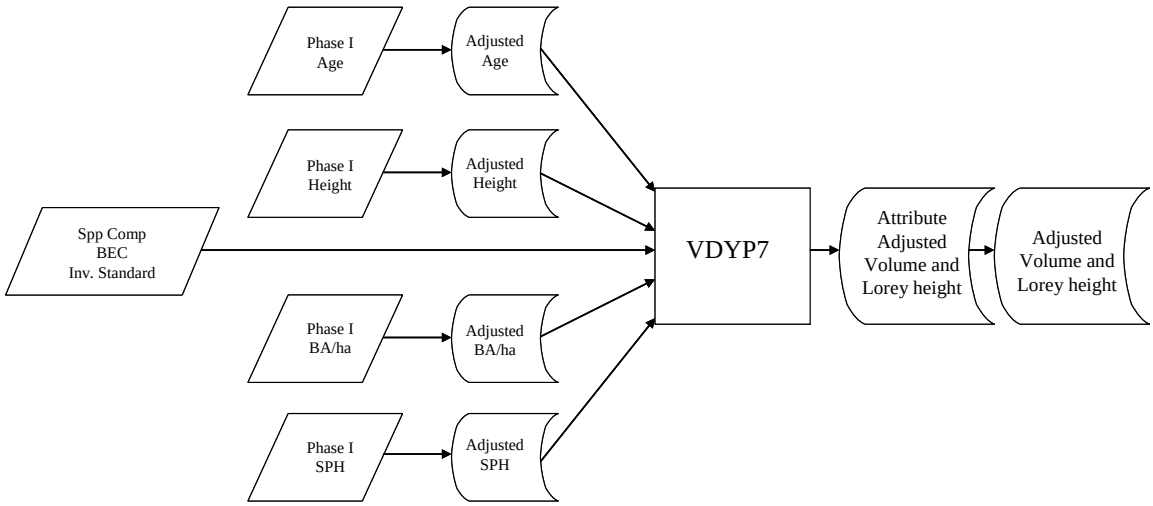

Figure 4. Interim procedures for adjustment of baseline VRI timber attributes.

[15] Ministry of Forests and Range. 2008. *Vegetation Resources Inventory Interim Procedures and Standards for Statistical Adjustment of Baseline VRI Timber Attributes*. Unpublished Report, January 2008. 36 pp.

4.0 RESULTS

4.1 NVAF

The average NVAF ratios for live immature and mature trees were 1.032 and 1.004 respectively (Table 12, Figure 5). The overall NVAF ratio for dead trees was 0.379 based on a sample size of two. This is obviously a small sample and could be improved by increasing the sample size, but it was approved for use by the MFR Volume and Decay Officer. The combined sampling error of all coniferous trees was 5.8% (95% confidence).

Table 12. TFL 47 NVAF ratios.

Live/ Dead	Maturity	Spp	No. Trees	Ratio	95% E%
Live	Immature	All	18	1.032	5.1
	Mature	All	21	1.004	10.3
Dead	All	All	2	0.379	352.9
All	*All*	*All*	*41*	*0.986*	*5.8*

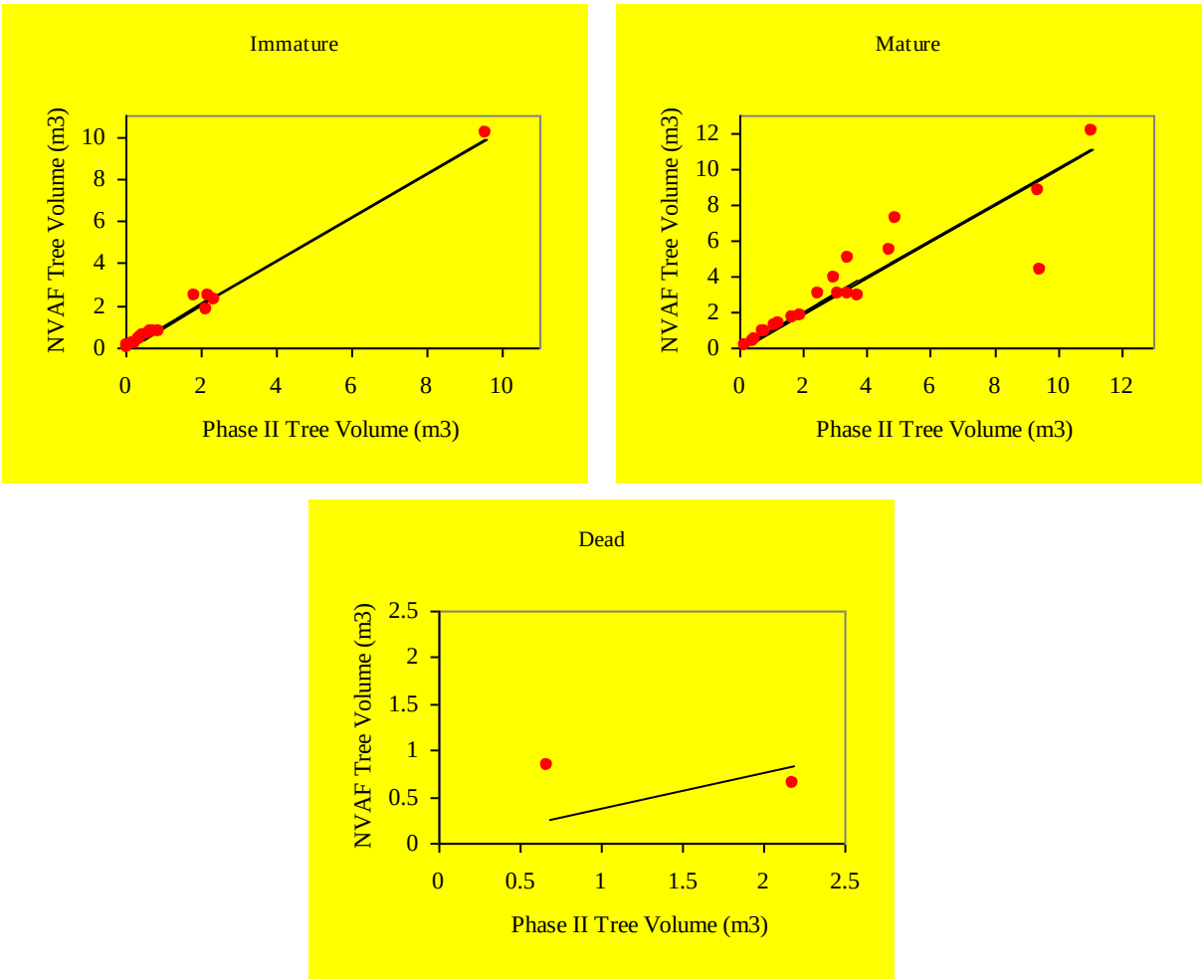

Figure 5. TFL 47 NVAF scatter plots.

4.2 Height

Two (2) plots[16] had no ground height observations, leaving 67 plots for height analysis. Overall, heights decreased by approximately 1% (Table 13, Figure 6) post-adjustment. The sampling error is relatively low at approximately ±6% (95% probability). The adjustment ratio was lowest (i.e., greatest decrease) in the "Other ≤ 100yrs" stratum at 0.910. Conversely, the adjustment ratio was highest (greatest increase) in the "Other > 100yrs" stratum at 1.130.

Table 13. Height adjustment statistics.

Stratum	Area (ha)	Pop. Avg. (m)	Sample Size	Sample Phase I Avg. (m)	Sample Phase II Avg. (m)	ROM	Predicted Avg. (m)	Error (m)	Error (%)
H ≤ 100yrs	40,643	26.6	24	26.4	25.6	0.969	25.7	1.7	6.4
Other ≤ 100yrs	17,295	26.0	16	28.3	25.7	0.910	23.6	3.5	14.7
H > 100yrs	17,063	33.1	17	30.8	30.4	0.989	32.7	5.4	16.4
Other > 100yrs	13,277	28.6	10	29.8	33.7	1.130	32.3	5.4	16.8
Total	*88,278*	*28.0*	*67*	*28.1*	*27.8*	*0.987*	*27.7*	*1.6*	*5.6*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

4.3 Age

One (1) plot[17] had no ground age observation, and 1 plot[18] was identified as an age outlier, and removed from the analysis. This left 67 plots for analysis. Overall, ages increased by approximately 39% post-adjustment (Table 14, Figure 7). The sampling error was large (approximately ±17%), mainly due to the age estimation in the "Other" strata. The adjustment ratio was highest (i.e., greatest increase) in the "Other > 100yrs" stratum at 1.671. Conversely, the adjustment ratio was lowest (i.e. smallest increase) in the "H ≤ 100yrs" stratum at 1.201.

[16] Sample 0055 did not have any site trees of the leading species (Yc) that had suitable height observations. Sample 0082 did not have any site trees corresponding to the leading species in the plot (Cw).

[17] Sample 0082 did not have any site trees corresponding to the leading species in the plot (Cw).

[18] Some ages in Sample 0021 for the leading species (Hw) were prorated ages, bringing the average total age for Hw to 2610 yrs.

Table 14. Age adjustment statistics.

Stratum	Area (ha)	Pop. Avg. (yrs)	Sample Size	Sample Phase I Avg. (yrs)	Sample Phase II Avg. (yrs)	ROM	Predicted Avg. (yrs)	Error (yrs)	Error (%)
H ≤ 100yrs	40,643	59	24	60	73	1.201	71	11	15.2
Other ≤ 100yrs	17,295	65	16	67	99	1.488	96	62	64.1
H > 100yrs	17,063	242	17	260	331	1.272	308	83	26.9
Other > 100yrs	13,277	229	10	207	346	1.671	382	150	39.3
Total	*88,278*	*121*	*67*	*122*	*169*	*1.392*	*168*	*28*	*16.6*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

4.4 Basal Area

All 69 observations were used for the basal area analysis. Overall, basal area increased by approximately 31% (Table 15, Figure 8) post-adjustment with a sampling error of ±9.4% (95% probability). The adjustment ratio was highest (i.e., greatest increase) in the "Other > 100yrs" stratum at 1.580. Conversely, the adjustment ratio was lowest (i.e., smallest increase) in the "Other ≤ 100yrs" stratum at 1.161.

Table 15. Basal area adjustment statistics.

Stratum	Area (ha)	Pop. Avg. (m^2/ha)	Sample Size	Sample Phase I Avg. (m^2/ha)	Sample Phase II Avg. (m^2/ha)	ROM	Predicted Avg. (m^2/ha)	Error (m^2/ha)	Error (%)
H ≤ 100yrs	40,643	48.2	24	46.6	59.9	1.286	61.9	8.8	14.3
Other ≤ 100yrs	17,295	41.0	16	42.5	49.4	1.161	47.6	11.7	24.5
H > 100yrs	17,063	52.0	19	58.2	77.3	1.328	69.0	13.3	19.3
Other > 100yrs	13,277	40.6	10	46.6	73.7	1.580	64.2	19.2	30.0
Total	*88,278*	*46.4*	*69*	*48.0*	*63.3*	*1.312*	*60.8*	*5.7*	*9.4*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

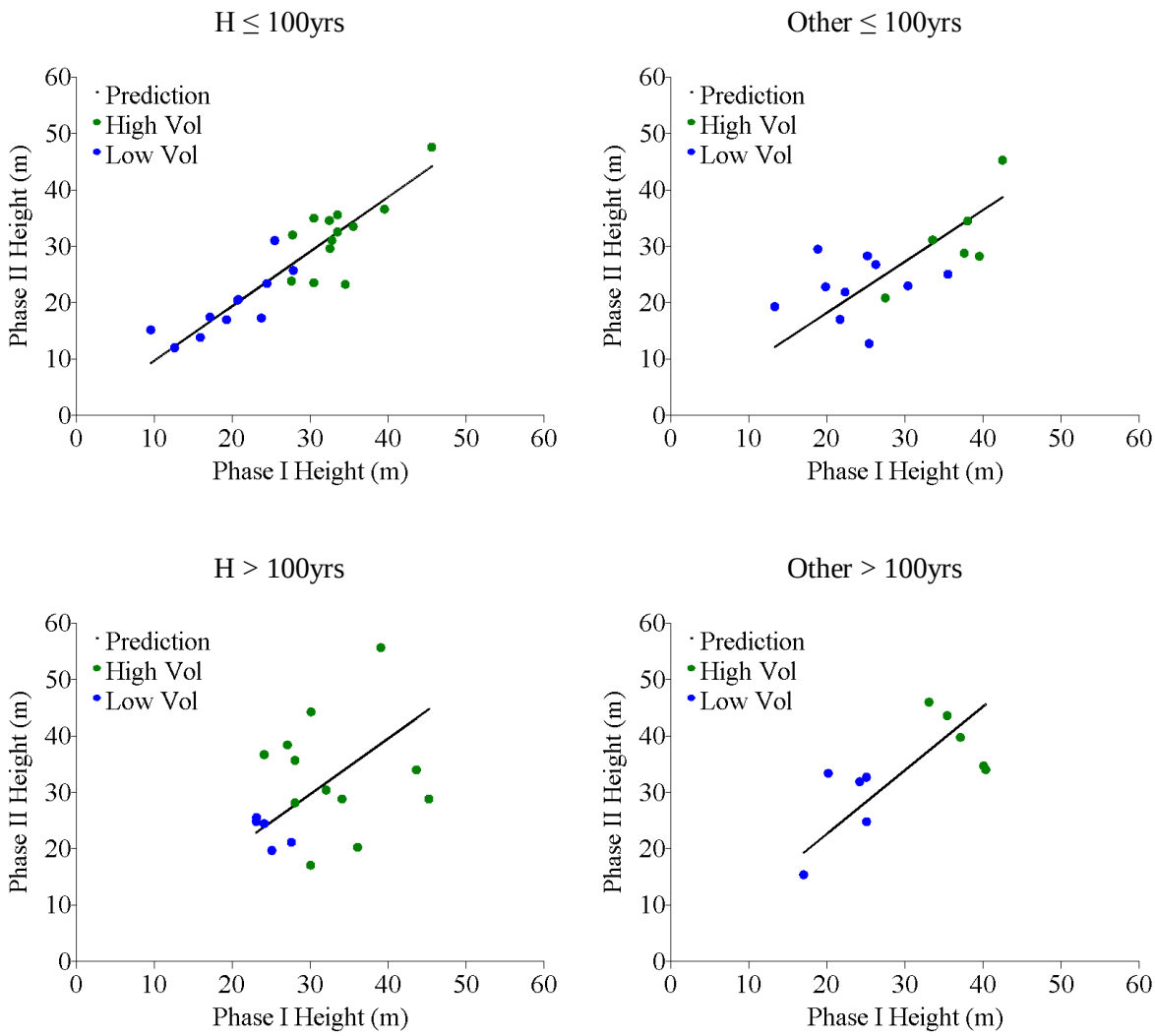

Figure 6. Height scatter plots by stratum.

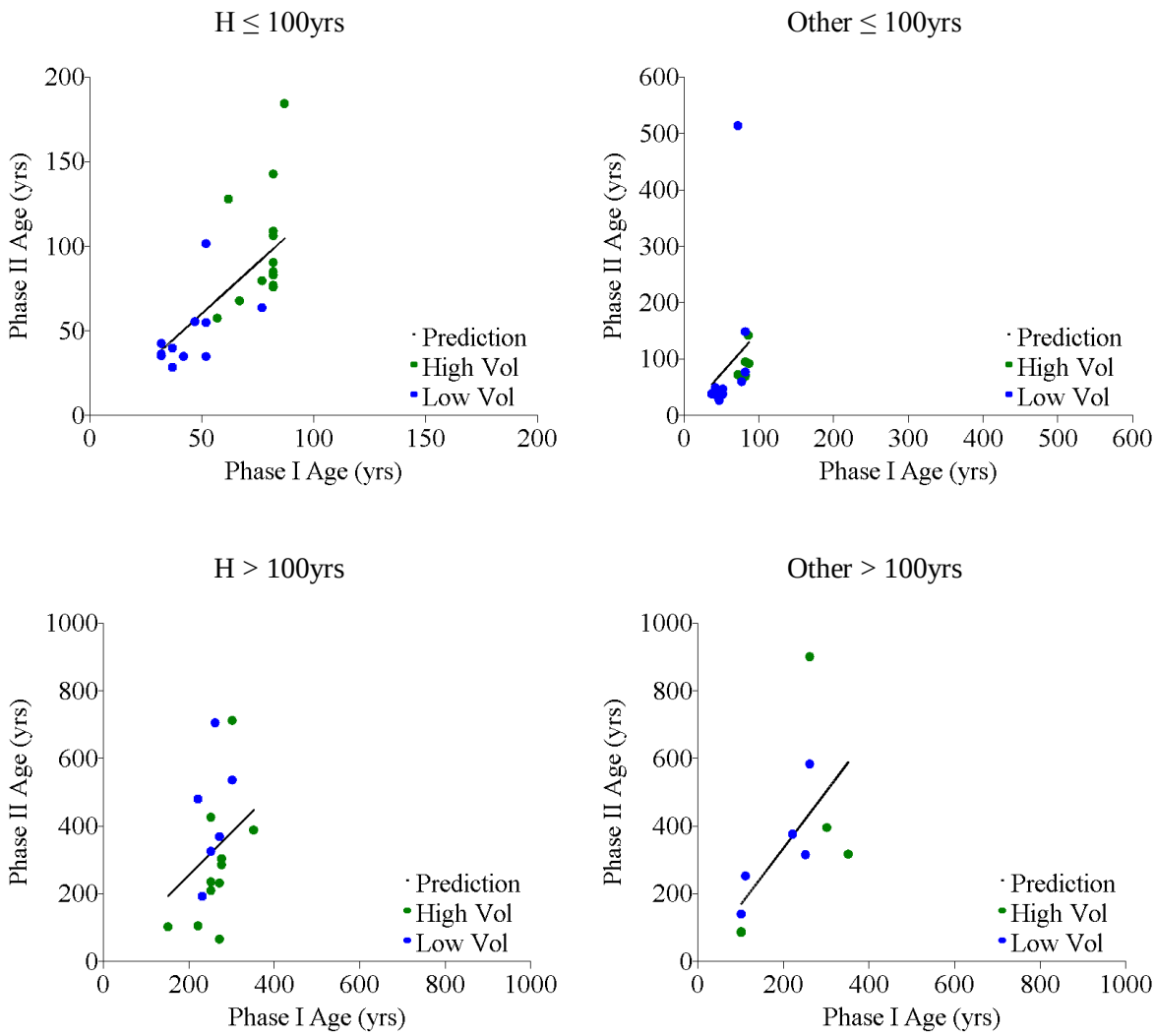

Figure 7. Age scatter plots by stratum.

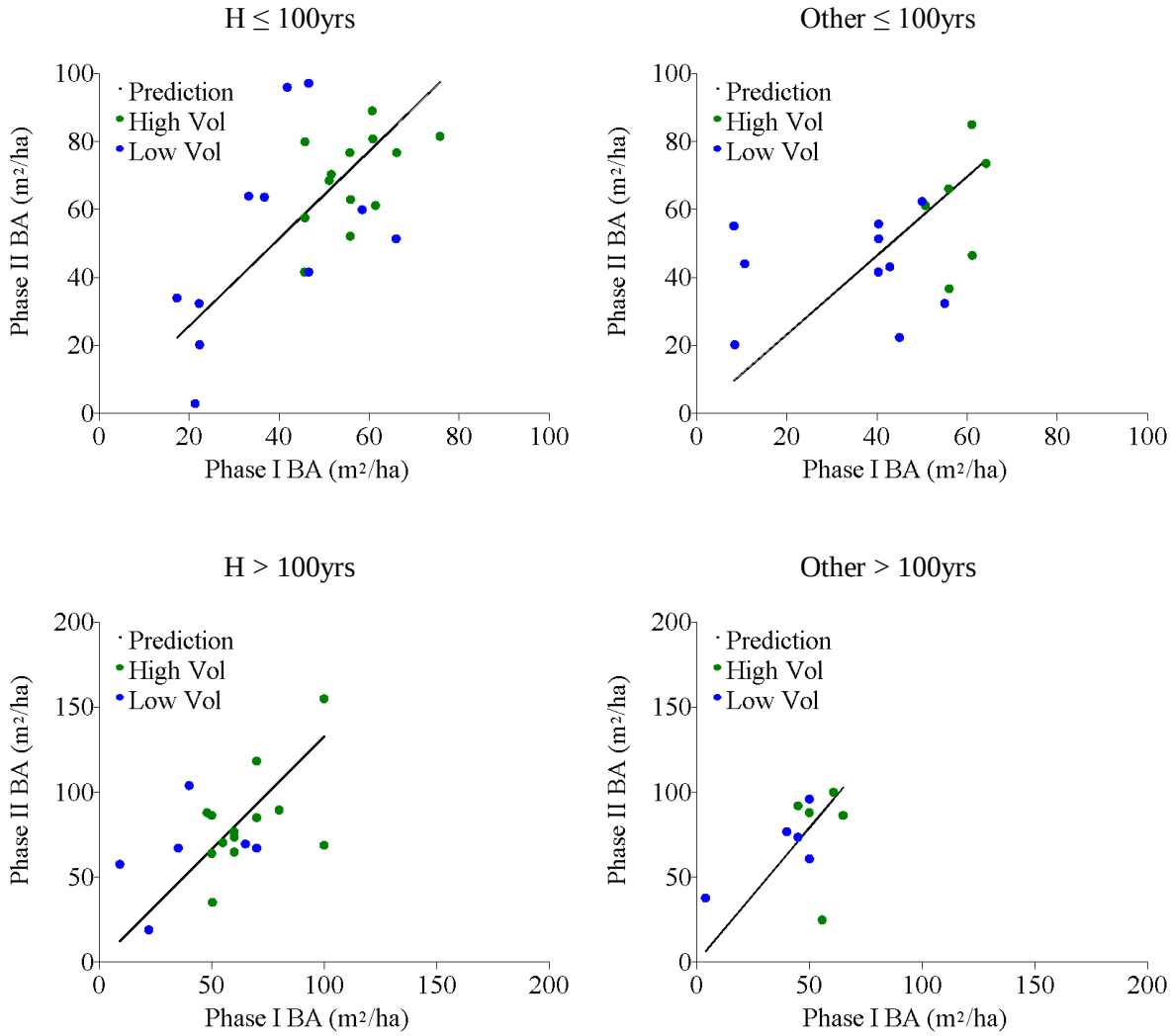

Figure 8. Basal area scatter plots by stratum.

4.5 Stem Per Hectare

All 69 observations were used for the stems per hectare analysis. Overall, stems per hectare were approximately doubled (Table 16) with a sampling error of ±21% (95% probability). The adjustment ratio was highest (i.e., greatest increase) in the "H ≤ 100yrs" stratum at 2.320. Conversely, the adjustment ratio was lowest (i.e., smallest increase) in the "Other ≤ 100yrs" stratum at 1.664.

Table 16. Stems per hectare adjustment statistics.

Stratum	Area (ha)	Pop. Avg. (trees/ha)	Sample Size	Sample Phase I Avg. (trees/ha)	Sample Phase II Avg. (trees/ha)	ROM	Predicted Avg. (trees/ha)	Error (trees/ha)	Error (%)
H ≤ 100yrs	40,643	743	24	698	1,620	2.320	1725	496	28.7
Other ≤ 100yrs	17,295	547	16	592	986	1.664	910	531	58.3
H > 100yrs	17,063	416	19	423	845	1.996	831	411	49.5
Other > 100yrs	13,277	363	10	368	783	2.130	773	310	40.1
Total	*88,278*	*585*	*69*	*575*	*1220*	*2.137*	*1249*	*256*	*20.5*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

4.6 Site Index

Site index is not directly adjusted in the VRI standard statistical adjustment. Instead, an adjusted site index is derived from adjusted height and age. The overall inventory-site-index decreased by approximately 3.4 m after adjustment (15.6%; Table 17). The largest decrease was in the "Other ≤ 100 yrs" stratum at 6.4 m. This is consistent with the height in this stratum decreasing and the age increasing.

Table 17. Site index change after adjustment.

Stratum	Area (ha)	Phase I SI (m)	Adjusted SI (m)	Difference (m)	Difference (%)
H ≤ 100yrs	40,643	26.3	22.4	-3.9	-14.7%
Other ≤ 100yrs	17,295	25.1	18.7	-6.4	-25.5%
H > 100yrs	17,063	14.0	12.4	-1.6	-11.6%
Other > 100yrs	13,277	14.6	14.0	-0.5	-3.8%
Total	*88,278*	*21.9*	*18.5*	*-3.4*	*-15.6%*

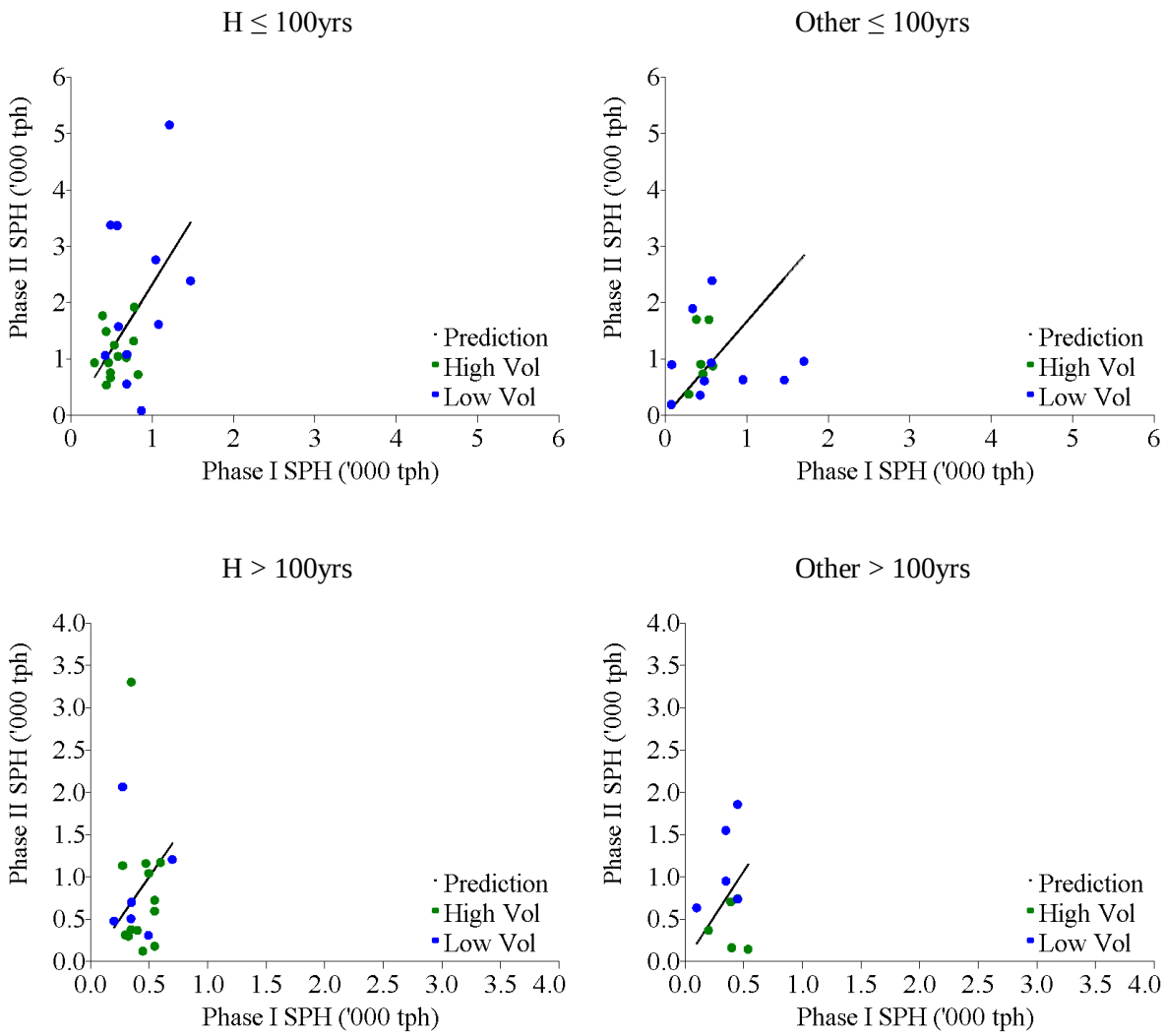

Figure 9. Stems per hectare scatter plots by stratum.

4.7 Lorey Height

All 69 plots were used to compute the Lorey height adjustment ratio. Overall, the attribute-adjusted Lorey height stayed approximately the same (Table 18, Figure 10) post-adjustment with a sampling error of ±5% (95% probability). Before attribute-adjustment, the average Lorey height for the target population was 25.4 m. Therefore, the adjusted average Lorey height actually represents a 3% decrease over the original average Lorey height (from 25.4 to 24.6 m).

Table 18. Lorey height adjustment statistics.

Stratum	Area (ha)	AA[19] Pop. Avg. (m)	Sample Size	Sample AA[19] Phase I Avg. (m)	Sample Phase II Avg. (m)	ROM	Predicted Avg. (m)	Error (m)	Error (%)
H ≤ 100yrs	40,643	22.7	24	22.8	22.5	0.987	22.4	1.7	7.8
Other ≤ 100yrs	17,295	21.0	16	23.5	25.3	1.078	22.6	2.2	9.8
H > 100yrs	17,063	28.5	19	27.3	27.5	1.004	28.7	3.1	11
Other > 100yrs	13,277	29.2	10	30.8	30.0	0.974	28.4	5.6	19.8
Total	*88,278*	*24.5*	*69*	*25.0*	*25.1*	*1.004*	*24.6*	*1.3*	*5.2*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

4.8 Live Net Merchantable Volume

4.8.1 Volume 12.5 cm+

All 69 plots were used to compute the volume adjustment ratio. Overall, the attribute-adjusted volume stayed approximately the same (Table 19, Figure 11) post-adjustment with a sampling error of ±11% (95% probability). Before attribute-adjustment, the average volume for the target population was 389 m^3/ha. Therefore, the adjusted average volume actually represents a 32% increase over the original average volume (from 389 to 512 m^3/ha).

Table 19. Volume 12.5 cm+ adjustment statistics.

Stratum	Area (ha)	AA[19] Pop. Avg. (m^3/ha)	Sample Size	Sample AA[19] Phase I Avg. (m^3/ha)	Sample Phase II Avg. (m^3/ha)	ROM	Predicted Avg. (m^3/ha)	Error (m^3/ha)	Error (%)
H ≤ 100yrs	40,643	497	24	485	469	0.965	480	76	15.9
Other ≤ 100yrs	17,295	345	16	398	410	1.029	354	118	33.4
H > 100yrs	17,063	597	19	605	674	1.114	664	112	16.8
Other > 100yrs	13,277	575	10	707	760	1.076	619	264	42.5
Total	*88,278*	*498*	*69*	*525*	*541*	*1.027*	*512*	*57*	*11.2*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

[19] AA = attribute adjusted

4.8.2 Volume 17.5 cm +

Although not a standard adjustment, volume was also adjusted for a utilization limit of 17.5 cm+ as this is the standard utilization used for timber supply on the coast. Adjustment results for this utilization limit are similar to those for the 12.5 cm+ utilization limit (Table 20, Figure 12).

Table 20. Volume 17.5 cm+ adjustment statistics.

Stratum	Area (ha)	AA[19] Pop. Avg. (m^3/ha)	Sample Size	Sample AA[19] Phase I Avg. (m^3/ha)	Sample Phase II Avg. (m^3/ha)	ROM	Predicted Avg. (m^3/ha)	Error (m^3/ha)	Error (%)
H ≤ 100yrs	40,643	466	24	458	436	0.953	444	69	15.6
Other ≤ 100yrs	17,295	334	16	382	385	1.007	336	115	34.2
H > 100yrs	17,063	590	19	600	666	1.111	655	112	17.1
Other > 100yrs	13,277	568	10	701	757	1.080	613	261	42.6
Total	*88,278*	*479*	*69*	*507*	*519*	*1.021*	*489*	*55*	*11.2*

Note: ROM is the ratio of means, error is the absolute 95% sampling error, and % error is the error relative to the predicted avg.

4.9 Forest Health

The occurrence of pest[20] and damage agents are summarized and expressed as a percent of the total number of stems[21] affected by species groups[22] (standardized to SPH) (Table 21).

Table 21. Pest incidence as a percentage of all measured trees.

Damage Agent	Species Group							
	H	C	Fdc	B	P	S	Deciduous	Other
Animal	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Stem Rot	0.7	0.0	0.6	1.2	0.0	0.0	0.0	0.0
Mistletoe	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stem Disease	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0
Abiotic	4.6	4.0	0.7	2.4	0.0	0.0	9.6	0.0
Treatment	1.5	0.1	0.6	0.0	0.0	0.0	0.0	0.0
Other	39.4	34.1	36.9	8.4	47.8	75.0	51.4	3.3

[20] Some pest codes were grouped. Pest codes for each "pest" are as follows: Animal = AX; Stem Rot = DD & DDF; Mistletoe = DMH; Stem Disease = DSB; Abiotic = N, NB, NGC, NW, NWS, NWT & NX; Treatment = TT, TL & TM; Other = U.

[21] An individual stem may have more than one pest.

[22] "Species Groups" are defined as follows: H = H, Hw & Hm; C = Yc & Cw; Fdc = Fdc & Fd; B = Ba & Bl; P = Pl, Plc & Pw; S = S & Ss; Deciduous = Dr, Mb & Kc; Other = Xh & Xc.

The key results from the VRI target population are that:

1. Unidentified pests ('U' or 'D') have the greatest prevalence among all species, followed by abiotic damage;
2. Mistletoe was prevalent in 5.9% of all hemlock stems; and
3. 23.6% of pines had stem disease.

Forest health data provides a broad indication of the occurrence of forest health indicators on the landbase. Each sample is a random point (not weighted by strata areas) within the target population and together the samples cover a range of variability in the TFL.

The associated incidence of damage indicators[23] is generally related to the pest incidence.[24] The most significant findings for damage indicators on TFL 47 from the tree data is that (Table 22):

1. Broken Tops are observed at a rate of 3 – 54% of all trees of all species; and
2. Scarring, dead tops, and forks are present in most species.

Table 22. Damage incidence as a percentage of all measured trees**.**

Damage Indicator	Species Group							
	H	C	Fdc	B	P	S	Deciduous	Other
Broken Top	8.8	7.0	7.3	3.4	18.1	54.3	21.3	3.3
Conk	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0
Crook	13.3	2.0	4.8	3.5	0.0	0.0	17.1	0.0
Decay	0.6	0.0	0.4	0.9	0.0	0.0	0.0	0.0
Dead Top	7.3	11.1	14.6	3.1	43.5	0.0	15.0	3.3
Fork	5.7	4.3	2.3	0.6	5.5	14.2	17.2	0.0
Frost Crack	1.9	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Scar	12.1	9.2	3.3	2.2	0.0	54.3	18.5	0.0
Other	0.1	0.3	0.0	0.2	0.0	0.0	0.0	0.0

H ≤ 100yrs

Other ≤ 100yrs

[23] Some damage indicators were grouped. Damage indicators are grouped as follows: Broken Top = BTP & BYP; Conk = CNK; Crook = CRO; Decay = BNK, DD, DDF & DDP; Dead Top = DTP; Fork = FRK; Frost Crack = NGC; Scar = SCA & CSA; Other = AFC & SNG.

[24] The damage indicators are not always associated with pests, as the cause of the underlying damage was often recorded as unknown by field crews.

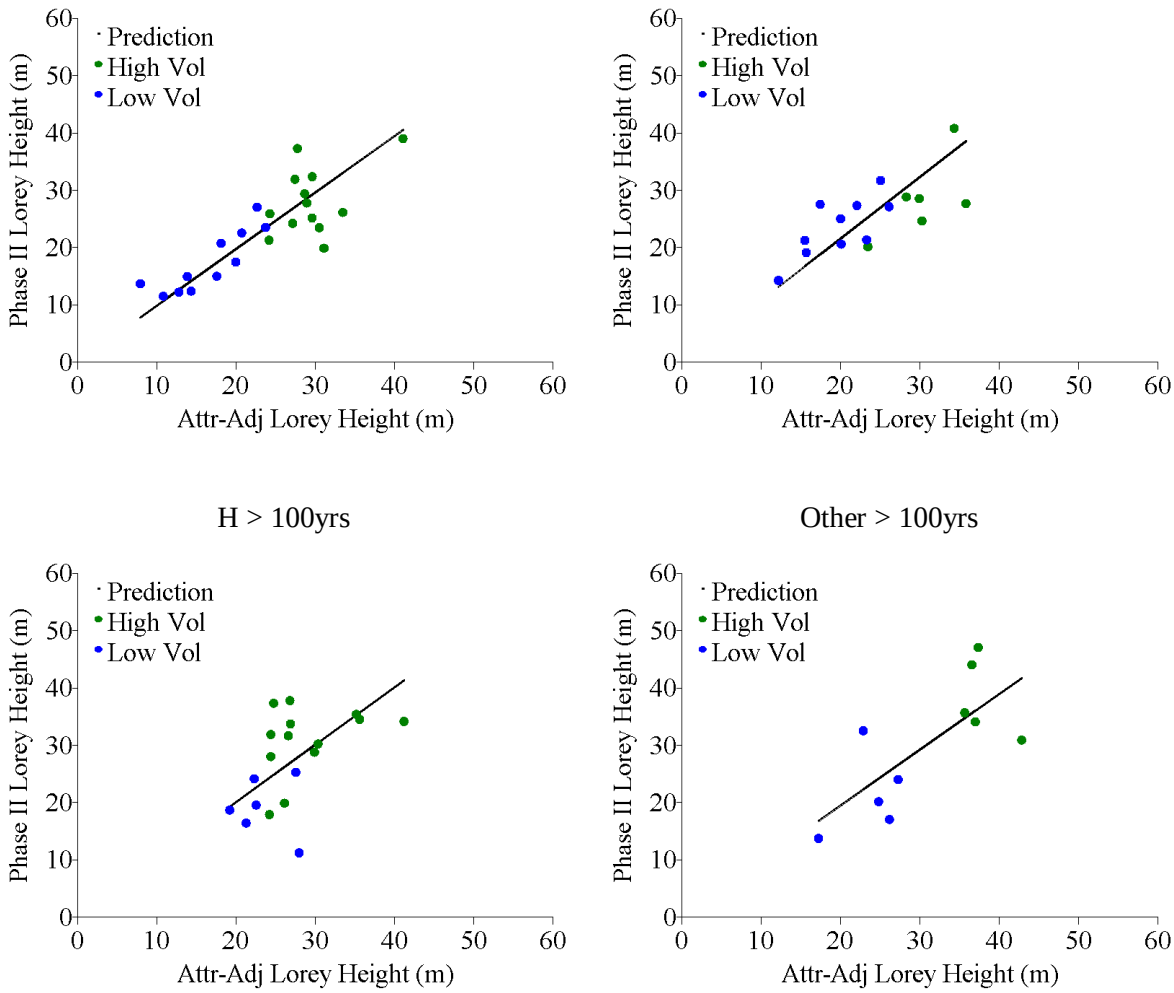

Figure 10. Lorey Height scatter plots by stratum.

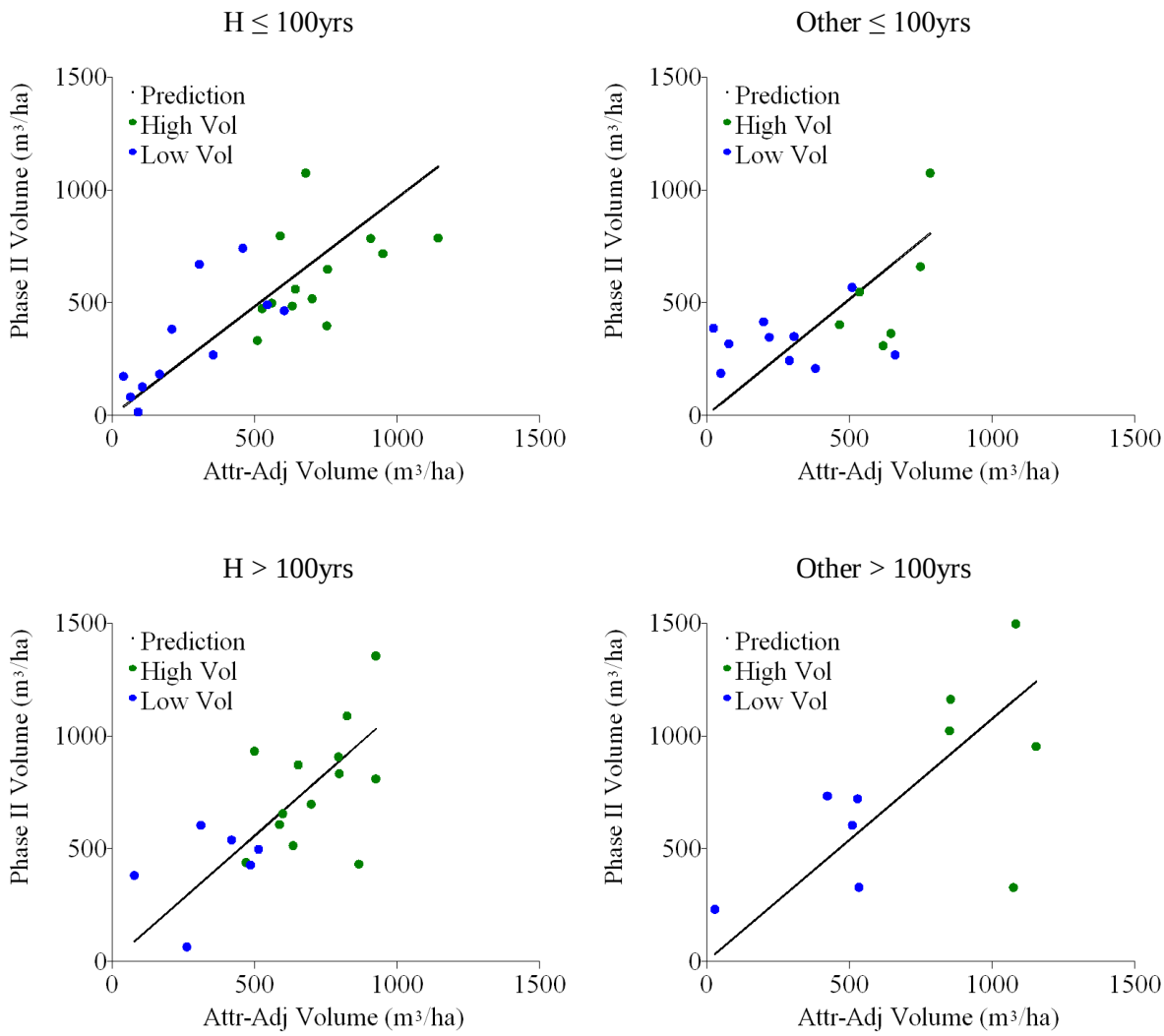

Figure 11. Net merchantable volume (12.5 cm+) scatter plots by stratum.

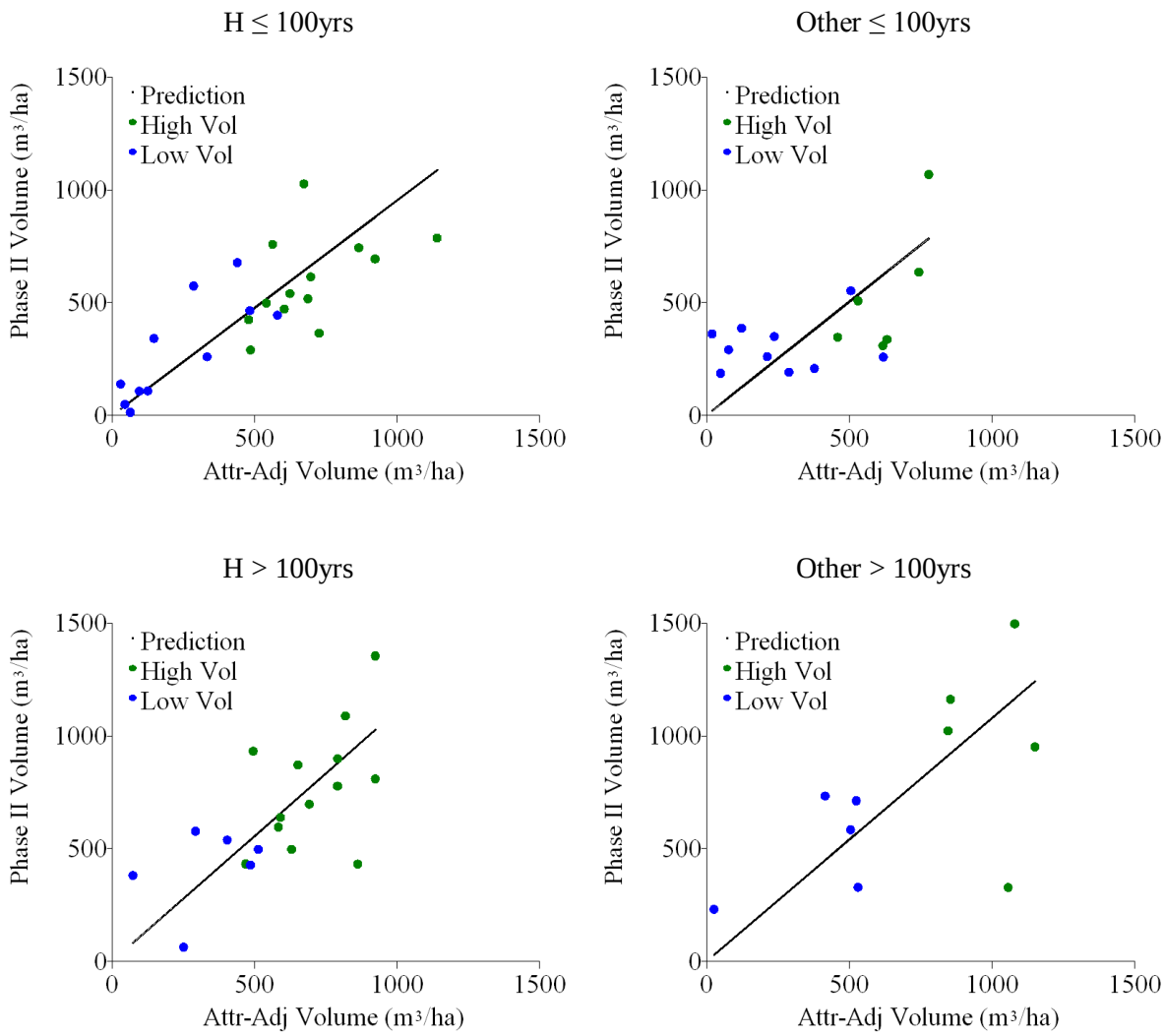

Figure 12. Net merchantable volume (17.5 cm+) scatter plots by stratum.

5.0 DISCUSSION

5.1 Accuracy and Precision

The statistical adjustment provides unbiased estimates for the scale at which the ratios were computed. In the case of TFL 47, unbiased estimates will be at the stratum level. There is always a possibility that local bias exists within a stratum. It would be inappropriate to estimate sub-stratum bias given the small sample size provided at a smaller scale.

The MFR-recommended precision for adjusted average volume at the management unit level is a sampling error of ±10% (95% probability). The overall sampling error achieved in this project was ±11% (95% probability). After the first preliminary analysis, TimberWest modified its sampling targets to maintain cost efficiency, and set a target sampling error of ±25% per stratum in 3 strata. This target has been reached for strata "H ≤ 100yrs" and "H > 100yrs" (15.9% and 16.8%, respectively). However, the sampling error increased in the "Other ≤ 100yrs" stratum, despite adding 4 plots (to 33.4%). Sampling error in this stratum decreased for all attributes, except volume. All four new plots are typed as red alder (Dr) leading in the Phase I inventory. The results suggest that VDYP7 doesn't predict volumes in Dr-leading stands well, or stands are incorrectly labelled.

It should be recognized that a higher sampling error represents uncertainty in the overall volume estimates.

5.2 Impact of Change

5.2.1 Live Volume

The overall live volume (12.5 cm+) increased by approximately 32% following adjustment (Table 23). The overall change in volume is reflective of volume increases in all strata, with the largest increase in the "Other > 100yrs" stratum (90%). There were relatively large increases in SPH and BA in all strata, which is strongly associated with volume estimates derived from VDYP7. The impact of change between the Phase II ground volumes and the attribute-adjusted volume is negligible with an increase in attribute-adjusted volume of approximately 3%, indicating that in general, VDYP7 adequately predicted volume in the target population with the adjusted input attributes. Table 24 shows the difference in volumes when volumes were estimated at 17.5 cm+ utilization.

Table 23. Volume change after adjustment (12.5 cm+).

Stratum	Area (ha)	Phase I	Attribute-Adjusted	Adjusted	Difference	
					(m^3/ha)	(%)
H ≤ 100yrs	40,643	409	497	480	71	17.4%
Other ≤ 100yrs	17,295	334	345	354	20	6.1%
H > 100yrs	17,063	443	597	664	221	50.0%
Other > 100yrs	13,277	326	575	619	293	89.8%
Total	*88,278*	*389*	*498*	*512*	*123*	*31.6%*

Table 24. Volume change after adjustment (17.5 cm+).

Stratum	Area (ha)	Phase I	Attribute-Adjusted	Adjusted	Difference	
					(m^3/ha)	(%)
H ≤ 100yrs	40,643	401	466	431	29.4	7.3%
Other ≤ 100yrs	17,295	329	334	326	-3.5	-1.1%
H > 100yrs	17,063	442	590	653	211.1	47.8%
Other > 100yrs	13,277	324	568	607	283.3	87.5%
Total	*88,278*	*383*	*479*	*480*	*96.3*	*25.1%*

5.2.2 Age

The age adjustment had a considerable impact on the age class distribution (Figure 13). The result was more area in age classes 5, 6, 7 and 9 and less area in age classes 2, 3, 4 and 8. However, the general shape of the age class distribution was maintained, with age classes 6, 7 & 8 having less representation than other age classes. The general trends observed can be attributed to ages increasing over the entire target population. Age class 2 covers the range of 21-50 and this figure only includes area for ages 30 and above as defined in the target population.

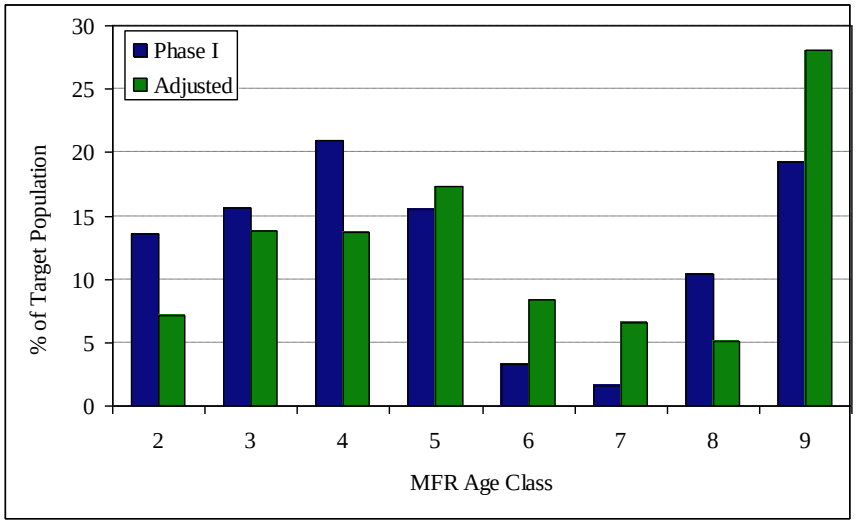

Figure 13. Change in MFR age class.

5.2.3 Lorey Height

The overall Lorey height decreased by about 3% following adjustment (Table 25). The small overall change in Lorey height is reflective of an increase in the "Other > 100yrs" stratum (+8.4%), and decreases in the "H ≤ 100yrs" and "Other ≤ 100yrs" strata (-8.8% & -4.4%, respectively). The impact of change between the Phase II and the attribute-adjusted Lorey height is negligible with an increase in attribute-adjusted Lorey height of less than 1%, indicating that in general, VDYP7 adequately predicted Lorey height in the target population with the adjusted input attributes.

Table 25. Lorey height change after adjustment.

Stratum	Area (ha)	Phase I (m)	Attribute-Adjusted (m)	Adjusted (m)	Difference	
					(m)	(%)
H ≤ 100yrs	40,643	24.6	22.7	22.4	-2.2	-8.8%
Other ≤ 100yrs	17,295	23.6	21.0	22.6	-1.0	-4.4%
H > 100yrs	17,063	28.7	28.5	28.7	0.0	0.0%
Other > 100yrs	13,277	26.2	29.2	28.4	2.2	8.4%
Total	*88,278*	*25.4*	*24.5*	*24.6*	*-0.9*	*-3.4%*

5.3 Risks and Uncertainties

5.3.1 Age Trend

The statistical adjustment removes the bias in each stratum. However, it is possible that an age-related trend exists within each stratum. All residuals were plotted against stand age to detect any age-related trend. None of the residuals had a significant relationship to age. Volume is the most important attribute and had no age correlations.

5.3.2 Residual Trend

In SPH and BA, a significant relationship existed between the residuals and the initial predicted values in some strata. This relationship is particularly noticeable in the "Other ≤ 100yrs" stratum for BA and SPH. MFR standards require attribute adjustment using a ratio of means. The observed trend indicates that perhaps a ratio of means is not the best estimator in this case. However, on average, estimates should be accurate on a stratum-level.

6.0 CONCLUSIONS

After adjustment, live, net merchantable volume increased by 3% over the attributed adjusted net merchantable volume and 32% over the initial Phase I volumes. Height, and Lorey height were largely unchanged. The biggest adjustment was to SPH with a 114% increase (from 585 to 1249). Basal area also increased by 31% (14.4 m2) and age increased by 39% (47 years). The increase in age resulted in a 16% decrease (3.4 m) in site index.

The overall sampling error volume was ±11% (95% probability); slightly greater than the target sampling error of ±10% (95% probability). This is largely due to the sampling error in the "Other ≤ 100yrs" stratum, where despite increasing the sample size the sampling error increased. The additional plots are typed as red alder (Dr) leading in the Phase I inventory suggesting that either VDYP7 doesn't predict volumes well in Dr-leading stands, or stands are incorrectly labelled.

A main source of uncertainty with this analysis is in the SPH estimations. Phase I SPH was under-estimated by approximately 114% with a sampling error of ±21% (95% probability). It is likely that this high sampling error and under-estimation may be related to the layer estimate of SPH used for comparison. Phase II estimates will include all trees measured within the plot, and may include trees from intermediate or suppressed tree layers.

6.1 Recommendations

A statistical adjustment was completed for TFL 47 using the standard MFR methodology. Unbiased estimates of height, age, and volume were obtained using the VRI statistical adjustment methods. These estimates represent the best available inventory estimates. Therefore, we recommend that:

> *Timberwest use the adjusted estimates of height, age, basal area, stems per hectare, and volume in the timber supply analysis base case.*

The forest health information could provide insight to particular forest health issues with a presence within the TFL. Therefore, we recommend that:

> *Timberwest consider the forest health statistics provided in this report as a starting point for investigating specific forest health issues.*

The new inventory data provides a rich set of information that can be used for a variety of broad scale strategic planning. Therefore, we recommend that:

> *Timberwest use the adjusted inventory for forest management planning*

The residuals analysis exhibited a significant relationship with Phase I predicted values for SPH and BA. Therefore, we recommend that:

> *TimberWest explore other non-standard adjustment methods (e.g. regression) for attributes that showed a significant trend.*

APPENDIX I – PHASE II SAMPLING WEIGHTS & PLOT LOCATIONS

Table 26. Phase II sampling weights and actual plot locations.

Proj.	Plot	Stratum	Sub-stratum	Mapsheet	Poly.	Zone	Easting	Northing	Weight
4701	1	>100 H	Low vol	092L047	70	9	658237	5593134	841
4701	2	≤100 H	High vol	092K042	857	10	305195	5587015	1,503
4701	3	≤100 H	Low vol	092L037	451	9	661120	5576742	1,919
4701	4	≤100 H	High vol	092K041	249	10	721008	5594482	1,503
4701	5	≤100 H	Low vol	092L058	324	9	680266	5599925	1,919
4701	6	≤100 H	High vol	092K043	377	10	317308	5589723	1,503
4701	7	≤100 H	Low vol	092K033	44	10	323627	5585265	1,919
4701	8	>100 H	Low vol	092L047	261	9	661163	5587815	841
4701	9	≤100 Others	High vol	092K024	20	10	331561	5573841	1,004
4701	10	≤100 H	Low vol	092K043	567	10	327637	5595303	1,919
4701	11	>100 H	High vol	092K042	281	10	307767	5593712	924
4701	12	≤100 Others	Low vol	092L060	42	9	712508	5599436	1,127
4701	13	≤100 H	High vol	092K033	278	10	323339	5582976	1,503
4701	14	≤100 Others	Low vol	092K043	130	10	323085	5596489	1,127
4701	15	>100 Others	Low vol	092L037	244	9	666449	5584451	1,319
4701	16	>100 H	High vol	092K041	507	10	298799	5592160	924
4701	17	≤100 Others	High vol	092K014	383	10	338809	5555447	1,004
4701	18	≤100 Others	High vol	092K044	8	10	332717	5589894	1,004
4701	19	>100 H	High vol	092K044	163	10	339058	5588555	924
4701	20	≤100 H	Low vol	092K014	25	10	335322	5563088	1,919
4701	21	>100 H	High vol	092L036	47	9	653929	5585043	924
4701	22	≤100 H	High vol	092K043	23	10	318151	5595690	1,503
4701	23	≤100 H	High vol	092K042	560	10	302041	5590644	1,503
4701	24	≤100 H	High vol	092K041	98	10	290435	5595515	1,503
4701	25	>100 Others	High vol	092L047	331	9	664498	5590082	1,336
4701	26	≤100 H	Low vol	092K051	286	10	290084	5606441	1,919
4701	27	≤100 Others	Low vol	092L037	173	9	669515	5574480	1,127
4701	28	≤100 H	High vol	092K043	78	10	321147	5595568	1,503
4701	29	≤100 H	High vol	092K024	272	10	335361	5571386	1,503
4701	30	≤100 H	High vol	092K052	226	10	310161	5601015	1,503
4701	31	>100 H	High vol	092K053	88	10	316441	5600361	924
4701	32	>100 H	High vol	092L047	423	9	665451	5585811	924

Proj.	Plot	Stratum	Sub-stratum	Mapsheet	Poly.	Zone	Easting	Northing	Weight
4701	33	>100 H	Low vol	092L047	213	9	663449	5593138	841
4701	34	≤100 H	High vol	092K041	31	10	290212	5597425	1,503
4701	35	>100 Others	Low vol	092K042	707	10	313716	5587678	1,319
4701	36	≤100 Others	Low vol	092K014	480	10	338598	5555156	1,127
4701	37	>100 H	High vol	092K042	292	10	309110	5594758	924
4701	38	>100 H	Low vol	092K034	143	10	342685	5581798	841
4701	39	≤100 Others	High vol	092K043	280	10	323509	5592171	1,004
4701	40	>100 Others	High vol	092K051	252	10	294922	5605037	1,336
4701	41	≤100 H	Low vol	092K024	98	10	335302	5572388	1,919
4701	42	≤100 H	Low vol	092K034	321	10	339047	5580835	1,919
4701	43	>100 Others	High vol	092L037	280	9	657054	5581078	1,336
4701	44	≤100 H	High vol	092K052	216	10	311481	5601358	1,503
4701	46	>100 Others	High vol	092K043	77	10	321218	5595099	1,336
4701	47	>100 H	High vol	092K042	281	10	307508	5593652	924
4701	48	≤100 H	High vol	092K014	186	10	763519	5562070	1,503
4701	49	≤100 Others	Low vol	092K024	59	10	332195	5572215	1,127
4701	50	>100 Others	Low vol	092K053	202	10	325178	5597853	1,319
4701	51	≤100 H	Low vol	092K033	103	10	329377	5584030	1,919
4701	52	>100 Others	Low vol	092K042	637	10	305205	5589722	1,319
4701	53	≤100 H	Low vol	092K043	370	10	315983	5589375	1,919
4701	54	>100 Others	Low vol	092K034	368	10	343049	5580973	1,319
4701	55	>100 H	Low vol	092L047	71	9	658715	5594042	841
4701	56	>100 H	High vol	092L027	132	9	665943	5573838	924
4701	57	≤100 H	Low vol	092K061	41	10	297202	5609447	1,919
4701	58	>100 Others	High vol	092L037	311	9	656854	5578367	1,336
4701	59	≤100 Others	Low vol	092K033	39	10	321818	5585039	1,127
4701	60	≤100 Others	High vol	092K041	33	10	294922	5605037	1,004
4701	62	≤100 Others	Low vol	092K035	63	10	344659	5578805	1,127
4701	65	>100 H	High vol	092L037	22	9	665787	5577921	924
4701	69	≤100 Others	Low vol	092K052	120	10	306377	5601166	1,127
4701	70	≤100 Others	Low vol	092L046	167	9	647847	5596096	1,127
4701	74	>100 H	High vol	092K033	151	10	327608	5584395	924
4701	79	≤100 Others	Low vol	092K043	150	10	324829	5594807	1,127
4701	82	>100 H	High vol	092K034	328	10	339735	5580908	924
4701	92	>100 H	High vol	092L046	101	9	654489	5594571	924
4701	97	≤100 Others	High vol	092K061	48	10	299402	5609264	1,004
4701	98	>100 H	Low vol	092K034	310	10	338267	5581364	841

APPENDIX II – PHASE I & II DATA

Table 27. Phase I data from sampled polygons.

			Phase I																
Sample	Map ID	Polygon ID	Area (ha)	Spp1	Ht1 (m)	Age1 (yrs)	SI1 (m)	SPH 7.5 (trees/ha)	BA 7.5 (m^2/ha)	Spp2	Ht2 (m)	Age2 (yrs)	SI2 (m)	Lorey height (m)	Vol. 12.5 (m^3/ha)	Vol. 17.5 (m^3/ha)	A.A. Lorey height (m)	A.A. Vol. 12.5 (m^3/ha)	A.A. Vol. 17.5 (m^3/ha)
1	092L047	70	18.5	Hm	36.2	302	9.6	495	35.2	Yc	23.1	262	10.9	22.5	238	234	27.6	420	405
2	092K042	857	17.9	Hw	45.6	82	35.4	294	66.2	Fdc	45.6	87	35.2	43.9	887	886	41.1	1144	1141
3	092L037	451	24.4	Hw	24.5	32	37.2	1081	58.5	Ba	26.6	32	40.2	22.7	472	459	20.7	545	484
4	092K041	249	9.9	Hw	32.8	62	32.5	436	51.6	Cw	32.8	62	31.2	33.9	534	532	30.5	644	625
5	092L058	324	22.0	Hw	17.2	32	28.0	869	21.4	Cw	12.9	32	23.5	15.1	99	84	13.9	92	64
6	092K043	377	66.0	Hw	39.6	82	30.4	582	60.9	Ba	39.5	82	30.7	36.4	773	771	33.5	951	923
7	092K033	44	52.1	Hw	20.7	52	22.0	1475	36.7	Cw	20.7	52	23.1	18.9	216	181	17.6	210	147
8	092L047	261	40.7	Hm	27.6	222	7.7	200	9.2	Yc	17.0	202	8.9	16.8	46	44	21.3	79	74
9	092K024	20	25.2	Fdc	42.5	87	33.2	465	61.1	Hw	40.5	87	30.1	39.1	757	756	34.3	783	779
10	092K043	567	45.0	Hw	19.3	32	31.1	1216	33.3	Cw	12.9	32	23.5	15.5	162	143	14.4	167	126
11	092K042	281	49.8	Hw	28.1	277	11.1	549	100.0	Ba	28.0	292	9.7	25.8	719	719	24.4	926	924
12	092L060	42	14.4	Dr	23.3	52	23.3	339	40.4	Hw	21.7	52	23.1	22.4	277	276	20.1	291	289
13	092K033	278	10.0	Hw	32.5	87	23.8	828	75.8	Fdc	36.3	92	27.8	30.2	741	735	27.8	908	866
14	092K043	130	19.5	Dr	19.3	42	20.6	1704	40.4	Hw	18.9	42	24.3	17.2	221	173	15.7	200	123
15	092L037	244	34.1	Yc	17.0	262	8.2	100	4.0	Hw	19.9	302	7.6	16.3	19	18	17.3	30	27
16	092K041	507	33.9	Hw	36.1	272	14.9	349	50.1	Yc	33.1	302	14.8	32.1	454	454	30.4	588	584
17	092K014	383	12.2	Fdc	37.6	72	32.5	291	56.0	Hw	35.7	72	29.6	33.5	577	577	30.3	619	618
18	092K044	8	21.1	Fdc	30.4	82	24.7	539	55.9	Hw	27.5	82	20.7	26.5	448	445	23.5	467	460
19	092K044	163	26.6	Hw	28.1	202	12.7	325	70.1	Cw	30.1	252	14.3	27.6	480	479	26.8	654	653
20	092K014	25	8.8	Hw	20.8	47	24.2	575	41.8	Fdc	21.6	47	25.9	19.9	254	250	18.1	307	287
21	092L036	47	13.1	Hw	39.1	302	15.8	349	55.0	Ba	41.2	302	15.4	37.0	617	617	35.2	795	792
22	092K043	23	88.7	Hw	35.5	82	27.0	775	55.8	Cw	33.6	82	26.3	32.3	622	612	29.6	756	698
23	092K042	560	36.9	Hw	27.6	67	24.1	783	51.2	Fdc	30.5	67	27.8	26.4	438	428	24.2	527	480
24	092K041	98	48.6	Hw	30.5	82	23.1	393	60.7	Fdc	33.5	82	27.2	29.4	532	531	27.4	680	673

			Phase I																
Sample	Map ID	Polygon ID	Area (ha)	Spp1	Ht1 (m)	Age1 (yrs)	SI1 (m)	SPH 7.5 (trees/ha)	BA 7.5 (m^2/ha)	Spp2	Ht2 (m)	Age2 (yrs)	SI2 (m)	Lorey height (m)	Vol. 12.5 (m^3/ha)	Vol. 17.5 (m^3/ha)	A.A. Lorey height (m)	A.A. Vol. 12.5 (m^3/ha)	A.A. Vol. 17.5 (m^3/ha)
25	092L047	331	21.4	Ba	37.1	262	14.4	449	65.0	Hw	35.1	302	13.9	33.2	691	690	35.7	1155	1151
26	092K051	286	183.7	Hw	9.6	37	14.7	588	17.4	Cw	6.4	37	10.2	8.7	40	36	7.9	40	31
27	092L037	173	4.5	Ba	13.3	72	11.8	567	8.3	Hw	18.0	152	9.2	14.0	29	25	12.2	25	20
28	092K043	78	9.9	Hw	34.5	82	26.2	538	55.8	Fdc	38.6	82	30.9	33.9	606	602	31.1	754	727
29	092K024	272	46.8	Hw	27.8	57	27.0	686	61.5	Fdc	29.7	57	30.1	26.4	512	507	24.3	633	604
30	092K052	226	17.3	Hw	33.5	82	25.4	489	45.7	Fdc	37.5	82	30.1	32.1	474	470	29.6	591	564
31	092K053	88	7.8	Hw	45.2	152	25.1	298	50.4	Cw	42.1	232	20.7	43.0	648	648	41.2	866	862
32	092L047	423	11.8	Hw	32.1	352	11.9	400	48.0	Yc	29.0	302	13.0	28.4	381	381	26.9	500	496
33	092L047	213	14.0	Hm	23.1	272	8.4	699	40.0	Ba	23.0	272	8.1	19.8	243	237	19.2	312	293
34	092K041	31	12.4	Hw	30.5	82	23.1	489	45.7	Cw	35.2	152	20.0	29.7	415	412	27.2	510	487
35	092K042	707	48.4	Fdc	26.1	252	14.5	449	45.0	Hw	24.2	112	14.8	22.8	292	290	24.8	512	505
36	092K014	480	4.9	Fdc	22.4	77	19.0	77	8.5	Pl	16.2	77	13.3	19.7	48	48	17.5	50	50
37	092K042	292	57.3	Hw	30.1	272	12.1	474	60.0	Ba	30.0	272	10.9	27.5	494	493	26.1	636	631
38	092K034	143	6.3	Hw	24.1	202	10.8	350	70.1	Cw	24.1	252	11.5	23.0	370	370	22.3	514	514
39	092K043	280	13.8	Fdc	39.6	82	31.6	586	61.2	Cw	35.6	82	27.9	34.0	621	616	29.9	646	633
40	092K051	252	15.4	Fdc	38.4	102	27.9	391	60.7	Hw	35.4	102	23.6	34.3	616	615	36.6	1084	1080
41	092K024	98	15.3	Hw	13.8	37	20.4	426	22.4	Fdc	15.9	37	23.7	13.7	88	84	12.8	107	96
42	092K034	321	24.5	Hw	12.6	42	16.9	1047	22.3	Cw	11.6	42	16.1	11.7	71	58	10.8	65	45
43	092L037	280	16.9	Ba	33.1	302	11.6	399	50.0	Hm	42.9	302	13.0	30.2	458	457	37.4	852	846
44	092K052	216	19.6	Hw	33.5	82	25.4	440	45.8	Cw	30.6	82	24.1	31.0	442	440	28.7	561	542
46	092K043	77	29.0	Fdc	40.4	102	29.2	539	55.7	Hw	35.5	82	27.0	34.6	611	607	37.0	1076	1057
47	092K042	281	49.8	Hw	28.1	277	11.1	549	100.0	Ba	28.0	292	9.7	25.8	719	719	24.4	926	924
48	092K014	186	50.9	Hw	32.5	77	25.6	466	55.9	Fdc	34.6	77	28.9	31.4	563	561	28.9	702	688
49	092K024	59	1.4	Cw	25.4	82	20.0	82	10.7	Hw	27.5	82	20.7	26.0	77	77	23.3	79	78
50	092K053	202	36.4	Cw	25.1	222	12.5	350	50.1	Hw	27.1	202	12.2	24.2	306	306	26.2	534	531
51	092K033	103	1.7	Hw	23.8	52	24.8	692	46.6	Cw	21.7	52	24.2	21.8	297	293	20.0	355	334
52	092K042	637	9.0	Fdc	24.0	252	13.0	450	40.0	Hw	20.2	102	13.0	21.0	243	241	22.9	424	416

			Phase I																
Sample	Map ID	Polygon ID	Area (ha)	Spp1	Ht1 (m)	Age1 (yrs)	SI1 (m)	SPH 7.5 (trees/ha)	BA 7.5 (m^2/ha)	Spp2	Ht2 (m)	Age2 (yrs)	SI2 (m)	Lorey height (m)	Vol. 12.5 (m^3/ha)	Vol. 17.5 (m^3/ha)	A.A. Lorey height (m)	A.A. Vol. 12.5 (m^3/ha)	A.A. Vol. 17.5 (m^3/ha)
53	092K043	370	21.9	Hw	25.5	77	20.0	689	66.0	Fdc	28.5	77	24.0	24.6	486	483	22.7	605	581
54	092K034	368	18.4	Cw	25.1	252	12.0	350	50.1	Fdc	30.1	252	16.5	25.1	300	299	27.3	530	525
55	092L047	71	13.4	Hm	38.7	302	10.8	346	22.1	Yc	25.1	302	11.3	24.5	166	163	28.0	263	251
56	092L027	132	26.2	Hm	43.6	302	13.4	447	50.1	Yc	36.2	302	16.2	31.7	462	461	35.6	699	692
57	092K061	41	5.0	Hw	27.9	52	29.1	493	46.6	Cw	25.9	52	28.3	25.8	369	366	23.7	459	440
58	092L037	311	15.2	Ba	40.1	352	13.8	200	45.0	Hm	46.7	402	14.0	36.7	477	476	42.8	855	855
59	092K033	39	71.4	Fdc	27.6	37	38.1	1463	42.9	Hw	25.2	37	34.0	22.5	322	279	20.0	307	238
60	092K041	33	12.2	Cw	38.0	86	29.0	385	64.2	Fdc	52.2	77	42.3	40.3	706	704	35.8	750	744
62	092K035	63	11.7	Dr	26.3	52	26.2	432	45.0	Fdc	28.9	52	31.4	24.6	368	367	22.1	382	378
65	092L037	22	13.9	Hw	34.1	252	14.3	548	70.1	Yc	35.1	252	16.7	31.4	630	628	29.9	825	819
69	092K052	120	20.6	Dr	29.2	62	27.8	482	50.0	Fdc	35.5	82	28.7	28.0	491	490	25.1	510	506
70	092L046	167	22.0	Dr	30.4	47	31.1	958	55.1	Ba	40.7	67	36.0	28.9	638	626	26.1	661	619
74	092K033	151	4.5	Hw	32.1	252	13.4	499	60.1	Cw	24.1	252	11.5	27.8	455	453	26.6	599	591
79	092K043	150	16.2	Dr	18.3	42	19.5	577	40.4	Hw	19.9	42	25.0	17.2	211	209	15.5	220	213
82	092K034	328	49.6	Hw	26.1	232	11.5	275	60.1	Cw	26.1	232	12.8	25.1	344	344	24.2	470	469
92	092L046	101	45.2	Hw	27.1	222	11.7	599	80.1	Ba	30.2	202	13.0	25.8	613	612	24.8	797	792
97	092K061	48	7.7	Fdc	36.5	82	29.4	439	50.8	Hw	33.6	82	25.4	31.9	513	511	28.3	537	531
98	092K034	310	13.8	Hw	25.1	232	10.6	275	65.1	Yc	23.1	242	11.2	23.2	350	350	22.6	486	486

Note: A.A. is the VDYP7 attribute-adjusted volume.

Table 28. Phase II data from sampled polygons.

Proj.				Phase II									
ID	Sample	Stratum	Sub-stratum	Spp	Case	Height (m)	Age (yrs)	SI (m)	BA 7.5	SPH 7.5	Lorey height (m)	Vol. 12.5 (m^3/ha)	Vol. 17.5 (m^3/ha)
4701	1	>100 H	Low vol	Yc	2	25.6	706	9.9	67.2	309	25.3	537	537
4701	2	≤100 H	High vol	Fdc	3	47.6	83	37.6	76.8	934	39.1	763	763
4701	3	≤100 H	Low vol	Hw	1	23.4	35	34.1	60.0	1617	22.6	476	451
4701	4	≤100 H	High vol	Hw	1	31.1	128	18.8	70.4	1491	23.5	543	524
4701	5	≤100 H	Low vol	Fdc	3	17.5	36	28.0	2.9	85	15.0	15	14
4701	6	≤100 H	High vol	Hw	1	36.6	85	27.5	80.9	1046	26.2	696	673
4701	7	≤100 H	Low vol	Hw	1	20.5	55	19.4	63.7	2389	15.0	371	331
4701	8	>100 H	Low vol	Hm	1	21.2	481	7.8	57.6	478	16.5	380	380
4701	9	≤100 Others	High vol	Fdc	3	45.3	92	34.1	85.1	736	40.8	1042	1036
4701	10	≤100 H	Low vol	Hw	1	17.0	43	22.0	64.0	5157	12.4	178	106
4701	11	>100 H	High vol	Hw	1	35.7	286	14.5	68.9	181	31.9	807	807
4701	12	≤100 Others	Low vol	Hw	2	17.0	47	21.6	41.7	1897	20.6	236	186
4701	13	≤100 H	High vol	Cw	3	34.6	185	18.3	81.6	727	37.3	761	721
4701	14	≤100 Others	Low vol	Hw	2	29.5	50	32.0	51.5	961	19.2	403	375
4701	15	>100 Others	Low vol	Hm	3	15.4	584	5.2	37.8	635	13.8	231	231
4701	16	>100 H	High vol	Hw	1	20.3	67	17.6	86.4	3305	30.3	605	594
4701	17	≤100 Others	High vol	Ss	3	28.8	73	19.6	36.8	376	24.7	300	300
4701	18	≤100 Others	High vol	Hw	2	20.9	95	14.2	66.2	1701	20.2	390	336
4701	19	>100 H	High vol	Cw	2	44.3	210	20.4	85.1	299	37.8	869	869
4701	20	≤100 H	Low vol	Hw	1	20.6	56	20.9	96.0	3369	20.8	650	557
4701	21	>100 H	High vol	Hw	1	55.7	2610	17.2	70.4	377	35.4	904	896
4701	22	≤100 H	High vol	Hw	1	33.5	76	27.0	76.8	1320	25.2	628	596
4701	23	≤100 H	High vol	Hw	1	23.8	68	20.6	68.6	1921	21.3	460	412
4701	24	≤100 H	High vol	Hw	1	35.0	91	25.4	89.1	1771	32.0	1042	995
4701	25	>100 Others	High vol	Ba	1	39.8	902	12.0	86.4	744	35.7	950	949
4701	26	≤100 H	Low vol	Hw	1	15.2	29	28.8	34.0	1577	13.7	168	135
4701	27	≤100 Others	Low vol	Hm	3	19.3	514	6.7	55.2	933	14.3	375	351
4701	28	≤100 H	High vol	Cw	3	23.3	77	19.4	52.2	1247	19.9	385	354
4701	29	≤100 H	High vol	Hw	1	32.0	58	31.0	61.3	1026	25.9	470	458
4701	30	≤100 H	High vol	Cw	3	35.6	143	24.3	80.0	669	32.4	772	736
4701	31	>100 H	High vol	Hw	1	28.8	103	20.5	35.2	314	34.2	430	430
4701	32	>100 H	High vol	H	3	30.5	389	11.1	88.0	368	33.8	930	930
4701	33	>100 H	Low vol	Hm	1	24.8	370	9.6	104.0	1207	18.7	602	576
4701	34	≤100 H	High vol	Hw	1	23.5	106	16.7	41.7	758	24.3	322	282
4701	35	>100 Others	Low vol	Hw	2	31.9	253	12.4	73.6	1858	20.2	602	582
4701	36	≤100 Others	Low vol	Fdc	3	21.9	60	22.3	20.3	194	27.6	181	181
4701	37	>100 H	High vol	Yc	3	17.1	232	11.2	76.8	1160	19.9	512	496
4701	38	>100 H	Low vol	Cw	2	24.5	326	10.9	67.2	701	24.2	496	496
4701	39	≤100 Others	High vol	Hw	3	28.3	72	29.3	46.6	878	28.6	353	327
4701	40	>100 Others	High vol	Hw	2	43.6	88	32.5	100.0	705	44.1	1452	1452
4701	41	≤100 H	Low vol	Fdc	2	13.9	40	20.4	20.2	1067	12.2	123	104

Proj.				Phase II									
ID	Sample	Stratum	Sub-stratum	Spp	Case	Height (m)	Age (yrs)	SI (m)	BA 7.5	SPH 7.5	Lorey height (m)	Vol. 12.5 (m^3/ha)	Vol. 17.5 (m^3/ha)
4701	42	≤100 H	Low vol	Hw	1	12.0	35	21.6	32.4	2761	11.5	79	47
4701	43	>100 Others	High vol	Hw	3	46.0	396	18.1	88.0	162	47.1	1020	1020
4701	44	≤100 H	High vol	Hw	1	32.6	109	21.8	57.6	539	29.4	483	483
4701	46	>100 Others	High vol	Cw	3	34.0	86	26.1	24.9	145	34.1	318	318
4701	47	>100 H	High vol	Hm	3	28.2	304	10.9	155.0	725	28.1	1350	1350
4701	48	≤100 H	High vol	Fdc	3	29.6	80	24.6	63.0	937	27.8	502	502
4701	49	≤100 Others	Low vol	Cw	1	12.8	149	12.0	44.1	903	21.4	308	283
4701	50	>100 Others	Low vol	Yc	3	24.8	377	10.5	60.8	1550	17.1	328	328
4701	51	≤100 H	Low vol	Hw	1	17.3	35	27.8	41.7	1082	17.5	260	252
4701	52	>100 Others	Low vol	Hw	2	33.4	140	18.6	76.8	737	32.6	731	731
4701	53	≤100 H	Low vol	Hw	1	31.1	64	28.3	51.5	557	27.1	451	431
4701	54	>100 Others	Low vol	Fdc	3	32.7	316	17.0	96.0	950	24.0	719	710
4701	55	>100 H	Low vol	Yc	2		537		19.0	506	11.2	64	64
4701	56	>100 H	High vol	Hm	1	34.0	713	12.3	64.0	124	34.5	695	695
4701	57	≤100 H	Low vol	Fdc	3	25.7	102	18.8	97.2	3378	23.6	719	657
4701	58	>100 Others	High vol	Ba	1	34.7	317	12.7	92.0	369	30.9	1158	1158
4701	59	≤100 Others	Low vol	Hw	2	28.3	39	37.3	43.2	627	25.1	340	340
4701	60	≤100 Others	High vol	Cw	1	34.5	142	23.8	73.6	1705	27.7	639	616
4701	62	≤100 Others	Low vol	Dr	1	26.8	38	33.3	22.4	361	27.4	202	202
4701	65	>100 H	High vol	Ba	3	28.8	427	8.5	118.4	596	28.8	1085	1085
4701	69	≤100 Others	Low vol	Cw	4	25.1	77	20.7	62.4	611	31.7	550	536
4701	70	≤100 Others	Low vol	Dr	1	23.0	27	33.1	32.4	635	27.2	260	251
4701	74	>100 H	High vol	Cw	2	36.7	236	18.4	73.6	1042	31.7	653	636
4701	79	≤100 Others	Low vol	Hw	2	22.8	37	32.5	55.8	2391	21.3	336	253
4701	82	>100 H	High vol	Cw	2				64.8	1134	17.9	437	431
4701	92	>100 H	High vol	Hw	1	38.4	106	25.4	89.6	1172	37.4	830	775
4701	97	≤100 Others	High vol	Hw	2	31.2	70	26.5	61.3	908	28.9	531	493
4701	98	>100 H	Low vol	Hw	1	19.7	193	9.0	69.6	2066	19.6	426	426

APPENDIX III – NVAF SAMPLES

Table 29. NVAF sample trees.

Sample Number	Batch	Species Group	Plot Maturity	Plot	Tree Number	Species	Live/ Dead	DBH (cm)	Age (yrs)
0003	1	Immature-H	Immature	S	001	H	L	18.9	32
0003	1	Immature-H	Immature	E	006	H	L	21.0	32
0003	1	Immature-O	Immature	E	004	B	L	48.4	32
0011	1	Mature-B	Mature	E	002	B	L	100.0	277
0011	1	Mature-H	Mature	E	004	H	L	74.0	277
0018	1	Immature-CW	Immature	N	001	Cw	L	73.5	82
0018	1	Immature-FD	Immature	S	007	Fd	L	27.2	82
0018	1	Immature-FD	Immature	W	008	Fd	L	36.2	82
0018	1	Immature-H	Immature	W	001	H	L	13.7	82
0018	1	Immature-H	Immature	S	010	H	L	21.5	82
0019	1	Dead	Mature	W	001	B	D	42.3	202
0019	1	Mature-B	Mature	N	010	Fd	L	91.0	202
0019	1	Mature-C	Mature	N	005	Cw	L	99.6	202
0019	1	Mature-H	Mature	W	002	H	L	44.9	202
0020	1	Immature-FD	Immature	N	006	Fd	L	27.9	47
0020	1	Immature-H	Immature	S	001	H	L	24.8	47
0031	1	Mature-C	Mature	N	005	Cw	L	56.1	152
0033	1	Mature-B	Mature	W	002	B	L	52.7	272
0033	1	Mature-C	Mature	N	003	Yc	L	29.4	272
0033	1	Mature-C	Mature	E	099	Yc	L	85.6	679
0033	1	Mature-H	Mature	E	003	H	L	72.9	272
0033	1	Mature-B	Mature	S	003	B	L	20.1	210
0033	1	Mature-B	Mature	E	001	B	L	42.3	723
0046	1	Immature-CW	Immature	E	004	Cw	L	26.8	102
0046	1	Immature-CW	Immature	N	003	Cw	L	48.1	102
0046	1	Immature-FD	Immature	W	004	Fd	L	96.4	102
0046	1	Immature-H	Immature	E	002	H	L	43.5	102
0047	1	Dead	Mature	N	003	H	D	42.1	272
0047	1	Mature-H	Mature	N	001	H	L	36.7	272
0047	1	Mature-H	Mature	S	003	H	L	55.5	272
0047	1	Mature-H	Mature	S	001	H	L	60.7	272
0047	1	Mature-H	Mature	S	004	H	L	66.6	272
0047	1	Mature-H	Mature	W	002	H	L	91.3	272
0050	1	Mature-B	Mature	W	005	B	L	33.5	222
0050	1	Mature-C	Mature	S	001	Yc	L	48.4	222
0050	1	Mature-H	Mature	W	008	H	L	32.8	222
0050	1	Mature-H	Mature	W	012	H	L	43.8	222
0051	1	Immature-FD	Immature	W	001	Fd	L	32.1	52
0051	1	Immature-H	Immature	W	003	H	L	12.8	52
0051	1	Immature-H	Immature	S	001	H	L	29.0	52
0051	1	Immature-H	Immature	E	001	H	L	31.1	52

Appendix D

Site Index Adjustment Report

Site Index Adjustment of Douglas-fir and Western Hemlock in the Low Elevation Biogeoclimatic Subzones on Tree Farm Licence 47

Prepared for

Jim McPhalen, RPF
T.F.L. Forest Ltd.
Nanaimo, BC

Project: TWV-061-008

March 6, 2002

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops BC

Executive Summary

This Site Index Adjustment (SIA) project was completed on the T.F.L. Forest Ltd. Tree Farm Licence (TFL) 47 areas on northern Vancouver Island and the islands in Johnstone Strait. The project was initiated in response to the Chief Forester's request that more accurate site index estimates be developed for this portion of the TFL.

The SIA project was completed over two years. In the first year, preliminary site index estimates were developed for Douglas-fir (Fd) and western hemlock (Hw) for all Coastal Western Hemlock (CWH) biogeoclimatic (BGC) subzones on TFL 47 to provide a basis for subsequent adjustment. Field site index estimates were collected during both field seasons in target second-growth stands throughout the CWH zone (except the CWHvm2). Finally, the preliminary site index estimates were adjusted using the results of the field sampling to produce site index estimates that can be applied to second-growth stands in the managed stand yield tables in the targeted CWH subzones. The ordinary least squares (OLS) adjustment method was used for Fd and the ratio of means (ROM) for Hw.

Spp	Adj. Method	Sample Size	Mean Prelim. SI	Mean Adj. SI	95% CI Mean Adj. SI
Fd	OLS	36	30.4	33.1	[31.4, 34.7]
Hw	ROM	58	25.7	27.4	[25.9, 28.9]

Following adjustment, the preliminary site index estimates for Fd were increased, on average, by 8.9%. This adjustment increased the area-weighted average site index of Fd in the target population by 2.7 m from 30.4 m to 33.1 m. For Hw, the field sampling produced a 6.6% increase over the preliminary site index estimates resulting in an area-weighted site index increase of 1.7 m from 25.7 m to 27.4 m. Both species adjustments were within the targeted sampling error of ±1.75 m.

We make the following recommendations from the results of this project:

1. Use the adjusted site index estimates from this project in the upcoming timber supply analysis. These estimates should be used with other silviculture and land base information to generate managed stand yield tables that more accurately reflect the expected growth in managed second-growth stands in the CWH (except the CWHvm2) on TFL 47.
2. Study the impact that elevation has on site productivity in the high elevation BGC zones (15% of the operable productive forest land base). A site index adjustment cannot be made to the CWHvm2 and the MH and AT BGC zones until ground-based estimates are obtained.
3. Establish a growth and yield monitoring program to track forest growth in the TFL 47 area. Corrective action could then be taken if monitoring shows that tree growth is different than expected.

Acknowledgements

We thank Jim McPhalen, *RPF* of T.F.L. Forest Ltd. for his guidance of this project. We also thank Albert Nussbaum, *RPF* of the Ministry of Forests Timber Supply Branch for his direction with the sample plan, and Kevin Hardy, *RPF* of the Ministry of Sustainable Resource Management for his work reviewing the field component of this project.

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1. INTRODUCTION

1.1 BACKGROUND

T.F.L. Forest Ltd. (TimberWest) completed this Site Index Adjustment (SIA) in response to the Chief Forester's recommendation[1] that more reliable site index estimates be developed for the next timber supply analysis in the Johnstone Strait and Bonanza Lake Management Units of Tree Farm Licence (TFL) 47. As in many areas of BC, site index estimates in the forest cover inventory tend to underestimate the expected growth of managed, second-growth[2] stands. This underestimation occurs because top damage and suppression inherent in older forests are not generally accounted for in the inventory site index.

Site index is a critical input variable in the models used to predict the growth and yield of existing and future forest stands. Underestimating site index can significantly reduce the volume estimates used in timber supply analysis. This can dramatically impact short and long term timber supply projections, stand and forest level planning, and timber flow sustainability commitments for certification initiatives.

1.2 PROJECT OBJECTIVE

The objective of this project was:

> *To develop reliable estimates of site index for managed, second-growth stands of Douglas-fir (Fd) and western hemlock (Hw) in the Coastal Western Hemlock (CWH) biogeoclimatic (BGC) zone in the Bonanza Lake and Johnstone Strait Management Units[3] of TFL 47.*

These site index estimates will be used with other silviculture information to generate yield tables for existing second-growth and future managed stands in the next timber supply analysis. Site index estimates for Pacific silver fir (Ba) and western redcedar (Cw) will be derived from the Hw site index estimates using the Ministry of Forests (MOF) site index conversion equations.

1.3 TERMS OF REFERENCE

Jim McPhalen, *RPF,* of TimberWest was the project leader. Hamish Robertson, *RPF*, of J.S. Thrower & Associates Ltd. (JST) was the project manager and Guillaume Thérien, *PhD* completed the data analysis. Dan Turner, *BScF FIT,* coordinated the field work (Figure 1). Dave Elstone, *RPF*, of EBA Engineering Consultants Ltd., administered the project on behalf of TimberWest. Project funding was provided through Forest Renewal BC. This project was completed over the 2000/01 and 2001/02 fiscal years.

Figure 1. SIA field crew members Tysen Leblanc, Scott MacKinnon, Kendra Wood, and Dan Turner with Vancouver Island Helicopter pilot, Wayne Green.

[1] Ministry of Forests. 1996. Tree Farm Licence TFL 47: Rationale for Allowable Annual Cut (AAC) Determination. Larry Pedersen, Chief Forester. This can be found at: http://www.for.gov.bc.ca/tsb/tsr1/ration/tfl/t47/httoc.htm

[2] Managed, second-growth stands are existing stands less than 31 years old and all future managed stands.

[3] The results of this project will not be applied to the Moresby Block on the Queen Charlotte Islands.

2. METHODS

2.1 OVERVIEW

This project was completed in three phases:

Phase 1: Preliminary site index estimates were developed for Fd and Hw for all forested site series in the CWHvm1, CWHxm, CWHdm, CWHmm1, and CWHmm2 subzones on TFL 47 to provide the basis for adjustment.

Phase 2: Field sampling was completed in suitable managed, second-growth stands to estimate site index from height and age measurements for Fd and Hw.

Phase 3: Final site index estimates were developed for the target species in the low elevation CWH subzones of the operable productive forest land base (OPFLB) by using the results of the field sampling to statistically adjust the preliminary site index estimates (Appendix I).

2.2 PHASE 1 - PRELIMINARY SITE INDEX

Preliminary site index estimates were developed for Fd and Hw for managed, second-growth stands in the CWHvm1, CWHxm, CWHdm, CWHmm1, and CWHmm2 using site index estimates from TFLs 37 and 45 (Appendix II).[4] These TFLs have similar ecological characteristics to TFL 47 so we assume that the productivity trends of these three TFLs are similar.

Bob Green of B.A. Blackwell & Associates Ltd. completed the Terrestrial Ecosystem Mapping (TEM) on the TFL in 1999. The forest cover database was developed and updated by TimberWest (July 2000). The forest cover and TEM dat7abases were combined using a Geographical Information System (GIS) to produce a resultant database of unique eco-polygons.

2.3 PHASE 2 - FIELD SAMPLING

2.3.1 Objective

The objective of the field sampling was:

> *To measure site index from a representative sample of Fd and Hw second growth stands across the target population.*

The specific goal was to collect enough Fd and Hw site index observations to achieve a sampling error of ±1.75 m (at a 95% confidence interval) for each species. In the sample plan, the precision target was set at ±1.5 m. However, following the first field season, the target was reset to ±1.75 m for both Fd and Hw due to the higher than expected variability in the field data.[5]

2.3.2 Target and Sample Populations

The target population is the portion of the land base where the results of this project will be applied. It comprises the operable portions of the CWHvm1, CWHxm, CWHdm, CWHmm1, and CWHmm2

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[4] Karel Klinka, *PhD RPF*, Bob Green, *MSc RPF,* Jim Thrower, *PhD RPF*, and Pat Bryant, *RPF* developed the preliminary site index estimates for TFL 37. The preliminary site index estimates for TFL 45 were developed by Karel Klinka, Bob Green, Guillaume Thérien, Tara McCormick, *BSc* and Hamish Robertson.

[5] Jim McPhalen received approval from Albert Nussbaum on January 16, 2001 to increase the target sampling error from ±1.5 m to ±1.75 m.

(98,140 ha). The sample population was all Fd- and Hw-leading stands between 21 and 80 years, total age, in the target population. The sample population covered 55,012 ha (56% of the target population).

2.3.3 Sample Size and Allocation

In order to focus on achieving the targeted sampling error for both species, the sample population was divided into one list of Fd-leading polygons and a second of Hw-leading polygons. Each list was sorted by preliminary site index prior to sample selection to ensure that the samples covered the range of site productivity. From each list, 60 sample polygons were systematically selected with a random start. Sample locations were randomly generated within each sample polygon using a 1 m grid.

2.3.4 Site Index

Top height and site trees were used to determine the field site index. Top height trees (T) were the largest diameter trees of the target species in each quadrant (100 m^2) that were suitable for estimating site index. The largest diameter suitable tree of the remaining target species was identified as the site tree (S). Suitable top height and site trees were:

1. Dominant or co-dominant.
2. Free of damage causing greater than 5% height loss.
3. Free of suppression and non-site factors.
4. Not wolf or open-grown trees.

The site index for each tree was computed using *Batch SiteTools* (version 3.2i). The plot site index for a given species was the average site index of all top height and site trees for that species.

2.4 PHASE 3 - FINAL SITE INDEX ESTIMATES

2.4.1 Statistical Adjustment of Preliminary Site Index Estimates

Adjusted site index estimates were developed for each target species in each eco-polygon by calculating a ratio between the area-weighted preliminary site index estimates and the corresponding field site index estimates. The adjustment ratio was then applied to each eco-polygon. The ordinary least squares (OLS), ratio of means (ROM), geometric mean regression (GMR), and mean of ratio (MOR) estimators were evaluated based on the variability of the field observations around their expected values and the observed relationship between field and preliminary site index estimates (Appendix III).

2.4.2 Site Index Conversion Equations

The sample sizes for Ba and Cw were too small to develop reliable adjustment equations for these species. Thus, the MOF site index conversion equations were used to generate site index estimates for these species from the adjusted site index estimates for Hw.

3. RESULTS

3.1 PRELIMINARY SITE INDEX ESTIMATES

Preliminary site index estimates for Fd and Hw were applied to each eco-polygon and were subsequently adjusted using the results of the field sampling. The average preliminary site index for the target population was 30.4 m for Fd and 25.7 m for Hw (Table 1).

Table 1. Preliminary site index estimates (m) for Fd and Hw in the target population.

Subzone	Area (ha)	Fd				Hw			
		Mean	Min.	Max.	Std. Dev.	Mean	Min.	Max.	Std. Dev.
CWHvm1	47,029	32.4	18.0	38.0	3.6	27.4	10.0	32.0	3.9
CWHxm	29,801	27.7	18.0	38.0	4.7	22.8	10.0	29.0	4.7
CWHdm	15,945	30.7	18.0	38.0	4.7	26.7	10.0	31.0	4.5
CWHmm1	4,069	26.3	18.0	37.4	3.2	23.0	10.0	31.0	4.0
CWHmm2	61	22.6	18.0	30.0	3.8	17.4	10.0	25.0	4.3
Total	*96,906*	*30.4*	*18.0*	*38.0*	*4.7*	*25.7*	*10.0*	*32.0*	*4.7*

3.2 FIELD RESULTS

Sixty-nine (69) plots were installed in the target population during the 2000 and 2001 field seasons. The first 31 Fd-leading polygons in the sample polygon list were assessed in the field.[6] Of these, 25 were established and six were rejected due to access problems, recent logging, and non-site factors (Table 2).[7] Five of the 25 installed plots were offset because the original point locations did not have suitable site trees. They were offset using a systematic 25 m grid.

Forty-eight (48) of the 60 Hw-leading polygons were assessed.[6] Forty-four (44) plots were installed and four were rejected because there were no suitable site trees. Ten (10) locations did not have suitable site trees and were offset.

Of the 69 plots, 25 contained observations for both Fd and Hw, 11 plots contained Fd observations only, and 33 plots contained Hw observations only, for a total of 94 observations. The average field site index for Fd was 31.6 m and the average Hw field site index was 28.1 m (Table 3).

Table 2. Rationale for plot rejection.

Plot	Reason for rejection
F-05	No reliable tie point
F-06	Suspected suppression (deciduous)
F-08	Suspected suppression (deciduous)
F-20	Logged in 2001
F-21	Logged in 2000
F-25	Suspected suppression (deciduous)
H-08	Suspected suppression (residuals)
H-12	Suspected suppression (deciduous)
H-20	Suspected suppression (deciduous)
H-24	Residuals and safety concerns

Table 3. Summary of field site index for the target species by subzone.

Ldg. Spp.	Subzone	Sample Size	Field Site Index (m)			Std. Dev.
			Mean	Min.	Max.	
Fd	CWHdm	10	33.8	20.5	41.7	7.4
Fd	CWHvm1	9	33.8	21.2	43.6	7.1
Fd	CWHxm	17	29.1	21.8	39.3	5.1
Fd	*All*	*36*	*31.6*	*20.5*	*43.6*	*6.6*
Hw	CWHdm	10	29.0	13.9	35.3	6.5
Hw	CWHvm1	28	29.2	16.5	40.2	6.0
Hw	CWHxm	20	26.2	15.4	39.9	7.1
Hw	*All*	*58*	*28.1*	*13.9*	*40.2*	*6.5*

[6] Sampling ceased for both Fd and Hw when the target sample error was achieved.

[7] Plots where suppression was suspected were either rejected during aerial reconnaissance or using aerial photos prior to visiting the field.

The distribution of the sample plots and target population were similar by subzone (Figure 2).

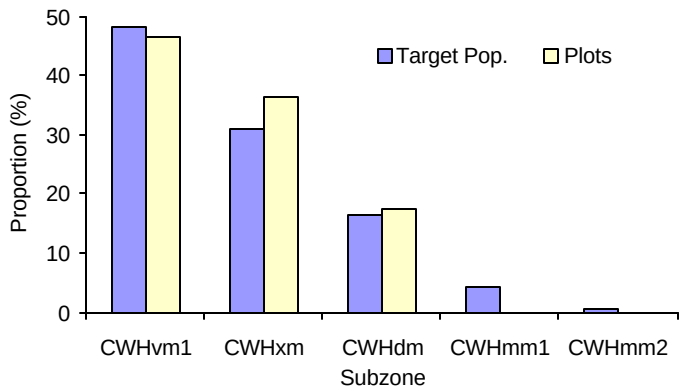


Figure 2. Distribution of the target population and sample plots by subzone.

3.3 STATISTICAL ANALYSIS

3.3.1 Overview

The OLS adjustment method was selected for Fd and the ROM method for Hw (Table 4). The ROM, MOR, GMR, and OLS regression (with and without intercept) adjustment methods were evaluated. All adjustment estimators yielded similar average adjusted site index estimates for Fd and Hw with similar standard errors (Appendix III). Therefore, the choice of the best adjustment estimator was a function of the behaviour of the estimator at the extreme of the sampled range.

Table 4. Adjustment statistics by species.

Spp	Adj. Method	Sample Size	Adj. Ratio	Adj. Intercept	Mean Prelim. SI	Mean Adj. SI	SE[a] Mean Adj. SI	95% CI Mean Adj. SI
Fd	OLS	36	1.034	1.6	30.4	33.1	1.67	[31.4, 34.7]
Hw	ROM	58	1.066	0.0	25.7	27.4	1.54	[25.9, 28.9]

[a]SE = sampling error.

Fd was adjusted using the OLS method because this method avoided extreme values at the upper end of the range and yielded site index estimates similar to those obtained on TFL 37. Other adjustment methods gave site index estimates close to the biological limit (about 45 m) at the upper range of preliminary site index. Using OLS, the maximum adjusted site index was 40.9 m. The maximum final adjusted site index on TFL 37 for site series present on TFL 47 was 42.7 m.

The ROM was considered the most appropriate estimator for Hw because the range of preliminary site index sampled was narrow relative to the corresponding ranges in field site index. This made it difficult to justify model assumptions of alternative estimators. We believe that for application outside the sampled range, the ROM is the most cautious approach. It assumes that the relative bias of preliminary site index estimates outside the sample range is similar to that observed in the sample.

3.3.2 Fd Adjustment

On average, the preliminary site index estimates for Fd were increased by 8.9% (Table 4, Figure 3). This adjustment increased the area-weighted average site index by 2.7 m from 30.4 m to 33.1 m, and shifted the population to more productive site classes (Figure 4). The targeted sampling error for Fd was achieved (±1.67 m).

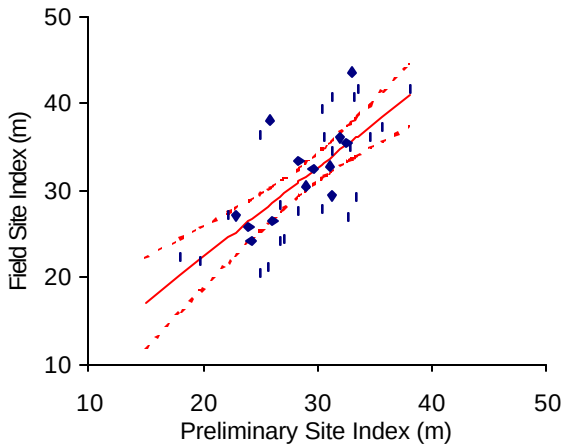


Figure 3. Field and preliminary site index estimates for Fd (solid line is estimated final site index; dashed line is 95% confidence interval of the estimate).

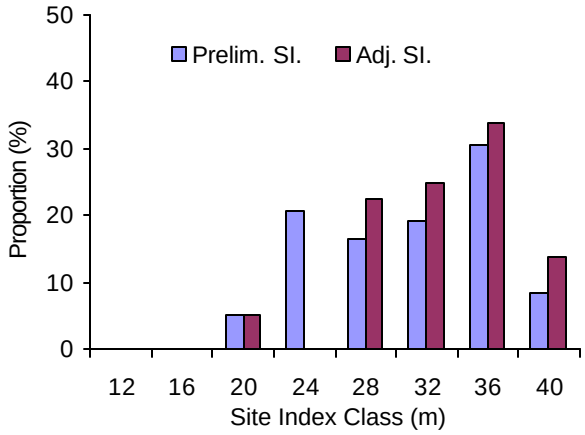


Figure 4. Area distribution of the target population among preliminary and adjusted Fd site index classes.

3.3.3 Hw Adjustment

The ratio adjustment for Hw resulted in an increase of 6.6% to the preliminary site index estimates (Table 4, Figure 5). Following adjustment, the area-weighted site index increased 1.7 m from 25.7 to 27.4 m resulting in an increase in the area distributed among the more productive site index classes. The targeted sampling error for Hw was achieved (±1.54 m) (Figure 6).

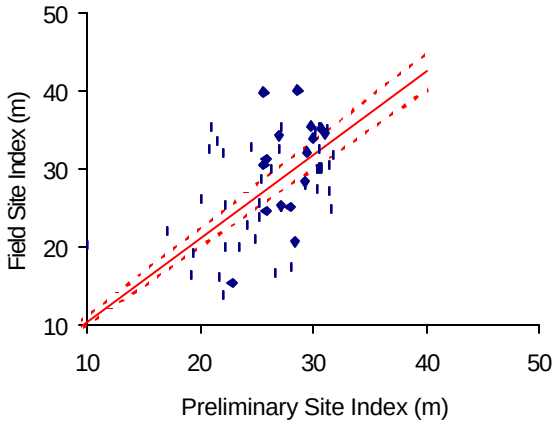


Figure 5. Field and preliminary estimates of site index for Hw (solid line is estimated final site index; dashed line is 95% confidence interval of the estimate).

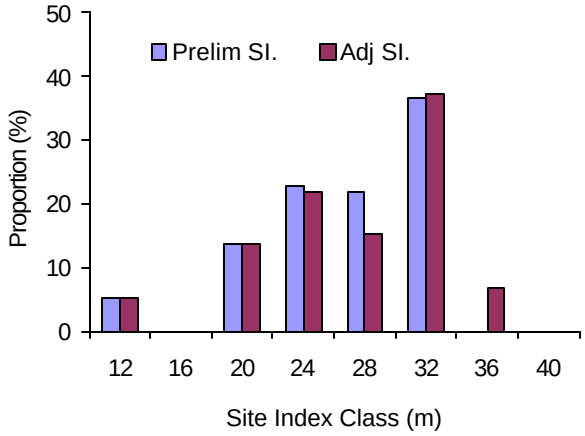


Figure 6. Area distribution of the target population among preliminary and adjusted Hw site index classes.

3.3.4 Site Index Conversion Equations

Site index estimates for Ba and Cw were developed using the MOF site index conversion equations[8] and the final Hw site index estimate. These equations are:

Ba: $SI_{Ba} = -1.2 + 0.9545 \times SI_{Hw}$

Cw: $SI_{Cw} = -2.0 + 0.9861 \times SI_{Hw}$

4. DISCUSSION

4.1 VARIATION BETWEEN PRELIMINARY AND FIELD ESTIMATES

There are several sources of variation between the preliminary site index and the field estimate of site index. The major sources of variation contributing to these differences included:

1. **Within-polygon variation:** If an entire polygon were sampled for site index, we would find a range of field estimates reflecting different growing conditions within the polygon. On TFL 47, there are 75,615 ha (77% of the target population) of eco-polygons mapped as complex site series in the TEM database. In these eco-polygons, the preliminary site index estimate is a weighted average of the constituent site series. When a plot is established in one of these polygons, the site series proportions within the 400 m^2 plot may differ from the site series proportions for the entire eco-polygon. In this project, 52 plots were located in eco-polygons with complex site series. Differences in site series distributions within individual polygons will introduce variation into the relationship between the field measurements and the preliminary site index estimate.

2. **Within site-series variation:** Natural variation in site index within a site series is another source of variation in the relationship between field and preliminary estimates. The site series classification is imposed on a continuum of ecological conditions. As a result, productivity within a site series will vary.

3. **Mapping error:** Mapping errors also contribute to the variation in preliminary and field estimates. The TEM database was developed using photo interpretation, visual air inspections, and limited ground sampling. We do not expect that eco-polygon boundaries or labels will always correspond to the actual distribution of site series on the ground.

4. **Different bias trends in the preliminary site index estimates:** One adjustment equation was applied to the preliminary estimates of each species. This assumes that the adjustment ratio was not different among subzones or among Management Units in the TFL. The sample size was too small to verify this assumption. Therefore, it is possible that while the overall average adjustment ratio is as reported in Table 4, the adjustment ratio in portions of the TFL could be different from the average, causing a localized bias in site index.

[8] Nigh, G.D. 1995. Site index conversion equations for mixed species stands. Research Report 01, BC MOF, Research Branch. 20 pp.

4.2 TARGET AND SAMPLE POPULATIONS

One of the challenges of statistically adjusting the preliminary site index estimates is that site index may only be reliably measured in a portion of the target population. Inference from the sample to the target population is conditional on the assumption that the relationships between field and preliminary site index estimates are consistent among eco-polygons in the sample and target populations. Such inference also assumes that the TEM and the Biogeoclimatic Ecosystem Classification are credible representations of the land base. We believe that these are reasonable assumptions.

5. RECOMMENDATIONS

1. Apply Adjusted Site Index Estimates in the Timber Supply Analysis

The main contribution of this project is the spatial resolution of species-specific estimates of site index for second-growth stands that can be applied in spatial timber supply analysis. Each eco-polygon in the target population has site index estimates for each of the target species based on its individual TEM attributes. Previously, each forest cover polygon had a single estimate of site index based on the height and age of the leading species in the inventory.

The adjusted site index estimates to be applied to existing and future managed stands are 2.7 m (or 10%) higher than the inventory site indices (Table 5). This increase was expected since the inventory site indices are estimated using photo-interpretation of older stands. The adjusted site index estimates should provide more accurate estimates of the long-run sustained yield for existing and future second-growth stands in future timber supply analyses.

Table 5. Comparison of adjusted site index to inventory site index.

Ldg. Spp.	Area (ha)	Mean Inv. SI (m)	Mean Adj. SI (m)	Difference (m)	Difference (%)
Hw	61,835	25.6	27.7	+2.1	+8
Fd	23,531	28.3	32.3	+4.0	+14
All	*85,366*	*26.3*	*29.0*	*+2.7*	*+10*

2. Establish a Growth and Yield Monitoring Program

We believe the site index estimates developed in this project are reasonable and should be applied in timber supply analysis. However, there remains some uncertainty with regard to the estimation of future growth. A growth and yield monitoring program should be developed to ensure that the estimates used in the timber supply analysis adequately reflect actual stand growth. A well designed and implemented program provides periodic measurements from a representative sample of second-growth stands on the TFL to compare actual growth with predictions. Corrective action could then be taken if comparisons show that tree growth is different than expected. Monitoring the growth and yield attributes in timber supply forecasts is an integral part of many certification schemes including the Sustainable Forestry Initiative.

3. High Elevation Sampling

An earlier objective of this project was to install enough plots in the CWHvm2 to adjust site index estimates in the higher elevation areas (CWHvm2 and the MH and AT BGC zones [15% of the OPFLB]). Currently, there are too few stands on the land base that are suitable for sampling so this portion of the project was not completed. Instead, this part of the budget was used to improve the confidence in the site index estimates in the low elevation areas. We recommend updating the site index estimates in the high elevation subzones once a greater proportion of the area is suitable for estimating site index.

APPENDIX I – LAND BASE CHARACTERISTICS

Geographic Location

TFL 47 consists of 15 geographically dispersed supply blocks located in Johnstone Strait, northern Vancouver Island, and the Queen Charlotte Islands. The Johnstone Strait and Vancouver Island portions of the TFL cover 134,850 ha, of which 115,195 ha (85%) is considered OPFLB (Table 4). The low elevation CWH subzones make up the target population and account for 98,140 ha (73% of the entire TFL, 96% of the OPFLB).

Table 6. TFL 47 land base net down statistics.

Land base	Area (ha)	*% of Total*	*% of OPFLB*
Entire TFL	134,850	*100*	
Non-Productive	11,769	*9*	
PFLB	123,080	*91*	
Inoperable	7,886	*6*	
Operable	115,195	*85*	*100*
AT and MH	5,237	*3*	*5*
CWH	109,958	*82*	*95*
CWHvm2	11,818	*9*	*10*
Low Elevation CWH	***98,140***	***73***	***85***

Forest Cover

Sixty-four (64) percent of the polygons in the target population are Hw-leading and 25% are Fd-leading (Table 7). The old-growth component comprises a relatively small portion of the target population; only 10% of the land base is 141 years or older. Approximately 80% of the land base is less than 80 years.

Table 7. Area (ha) distribution by leading species and age groupings in the OPFLB.

Ldg.	Age Class										Total	
Spp.	0	1-20	21-40	41-60	61-80	81-100	101-120	121-140	141-250	251+	(ha)	(%)
Hw	143	9,144	13,698	8,833	18,608	4,573	1,521	703	175	4,944	*62,342*	*64*
Fd	67	6,267	3,877	1,693	8,302	1,997	110	40	19	1,679	*24,050*	*25*
Cw	32	580	261	321	1,057	99	1	34	11	2,427	*4,823*	*5*
Dr	21	109	157	623	3,311	175	13				*4,409*	*4*
Others	27	515	332	149	685	252	112	40	25	380	*2,516*	*3*
Total (ha)	*291*	*16,614*	*18,326*	*11,619*	*31,964*	*7,095*	*1,756*	*816*	*229*	*9,429*	*98,140*	
(%)	*0*	*17*	*19*	*12*	*33*	*7*	*2*	*1*	*0*	*10*		*100*

Ecological Profile

The CWHvm1 (48%) is the largest subzone in the target population (Table 8). The CWHxm (31%) and CWHdm (16%) are other significant subzones present on the TFL. The CWHmm1 and CWHmm2 are only marginally present. Hw is the leading species in all subzones, while Fd is mainly present in the CWHxm and CWHdm subzones. The zonal site series and the drier than zonal 03 site series are the two most common site series present (Table 9). Site series 03 is the dominant site series in the CWHxm, CWHmm1, and CWHmm2 subzones.

Table 8. Area (ha) distribution by leading species and BGC subzone in the OPFLB.

Ldg. Spp.	Subzone					Total	
	CWHvm1	CWHxm	CWHdm	CWHmm1	CWHmm2	ha	%
Hw	33,508	17,164	8,271	3,359	40	*62,342*	*64*
Fd	8,184	10,892	4,661	294	19	*24,050*	*25*
Cw	3,049	699	633	443	0	4,823	5
Dr	1,403	767	2,235	5	0	*4,409*	*4*
Others	1,133	1,042	235	103	3	*2,516*	*3*
Total (ha)	*47,276*	*30,563*	*16,035*	*4,204*	*61*	*98,140*	
(%)	*48*	*31*	*16*	*4*	*0*		*100*

Table 9. Area (ha) distribution by site series in the OPFLB.

Site Series	Subzone					Total	
	CWHvm1	CWHxm	CWHdm	CWHmm1	CWHmm2	ha	%
01	17,263	9,688	4,914	738	12	*32,614*	*33*
01p	248	273	6	0	0	*526*	*1*
01s	1,141	0	0	0	0	*1,141*	*1*
02	1,110	2,663	588	324	15	*4,700*	*5*
03	13,086	11,112	3,660	2,573	33	*30,464*	*31*
04	20	56	31	0	0	*106*	*0*
05	5,116	2,600	2,429	35	0	*10,179*	*10*
06	2,048	975	988	213	0	*4,223*	*4*
06p	187	169	142	84	0	*582*	*1*
06s	661	0	0	0	0	*661*	*1*
07	4,375	1,430	2,234	5	0	*8,044*	*8*
08	0	0	24	0	0	*24*	*0*
09	116	0	0	0	0	*116*	*0*
10	70	0	0	0	0	*70*	*0*
11	0	78	82	13	0	*172*	*0*
12	31	361	695	26	0	*1,112*	*1*
13	90	13	0	0	0	*103*	*0*
14	691	0	0	0	0	*691*	*1*
15	0	1	0	0	0	*1*	*0*
20	776	385	154	59	2	*1,376*	*1*
NP	247	763	90	135	0	*1,234*	*1*
Total (ha)	*47,276*	*30,563*	*16,035*	*4,204*	*61*	*98,140*	
(%)	*48*	*31*	*16*	*4*	*0*		*100*

APPENDIX II – PRELIMINARY SITE INDEX ESTIMATES

Table 10. Preliminary site index estimates (m) for the low elevation CWH subzones.

Site Series	CWHdm		CWHxm		CWHmm1		CWHmm2		CWHvm1	
	Fd	Hw	Fd	Hw	Fd	Hw	Fd	Hw	Fd	Hw
01	32	29	31	27	32	29	30	25	34	30
01p	31	28	30	26					33	29
01s	31	28	26	24					26	25
02	18	10	18	10	18	10	18	10	18	10
03	25	22	24	20	25	22	22	18	29	23
04	28	22	27	20	28	22	25	20	30	23
05	35	30	35	28	35	30	35	26	37	31
06	33	31	32	28	33	31	31	27	34	32
06p	32	30	31	27	32	30			33	31
06s			26	23					26	23
07	38	31	38	29	38	31	31	27	38	32
08	38	31	38	29	38	31	38	26	38	32
09							8	8	38	32
10								21	38	32
11	18	10	18	10	18	10				
12	24	20	24	20	24	20			18	22
13			38	29					24	10
14									24	20
15			24	20						
20	25	22	24	20	25	22	22	18	29	23

APPENDIX III – STATISTICAL ADJUSTMENT METHODS

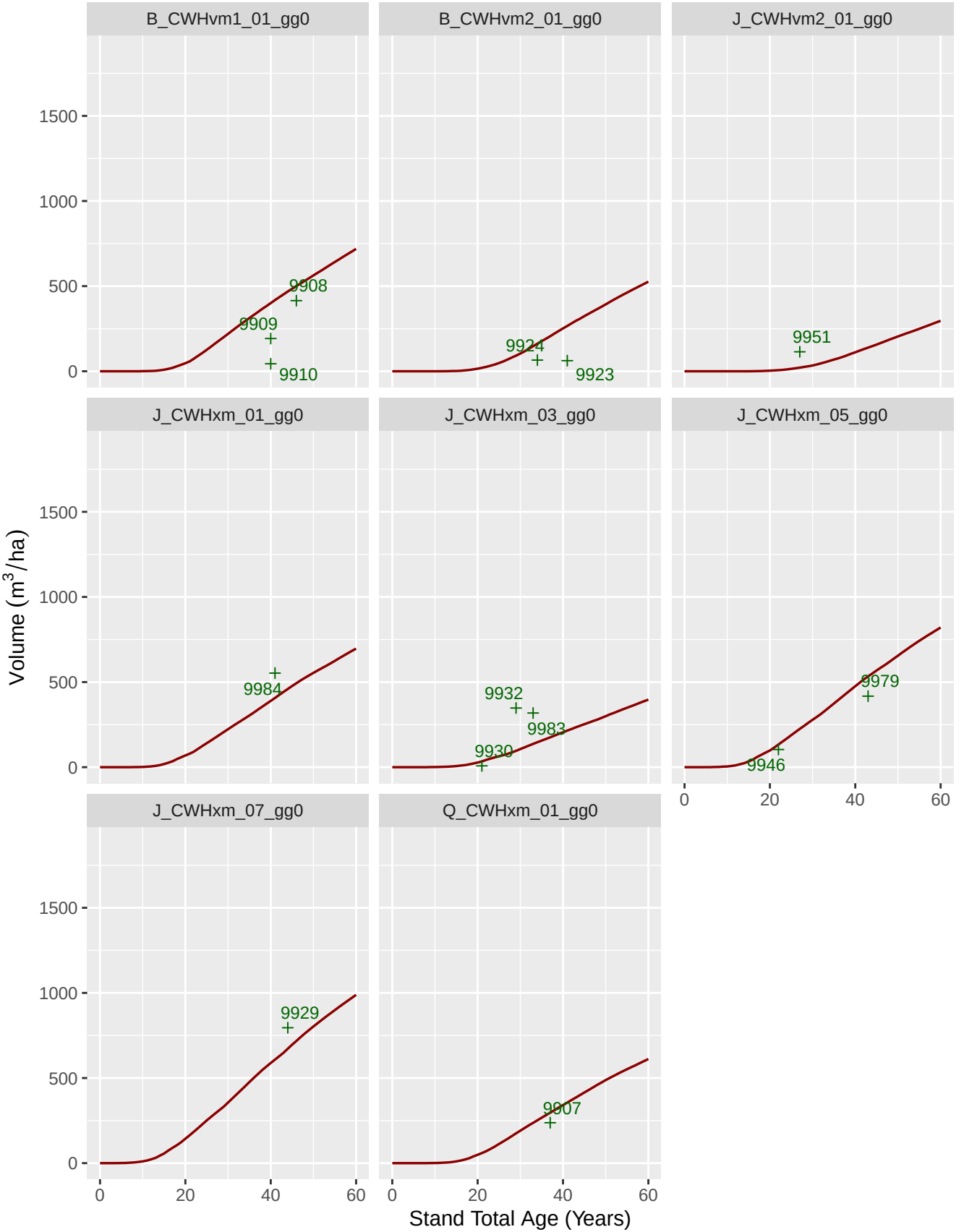
Table 11. Potential adjustment ratios used for each of Fd and Hw.

Spp	Adjustment Type	n	df[a]	Ratio	SE Ratio	Ratio Low CI[b]	Ratio Upper CI	Intercept	SE Intercept	Intercept Low CI	Intercept Upper CI	Avg. Prelim. SI	Avg. Adj. SI
Fd	***OLS with intercept***	***36***	***34***	***1.034***	***0.175***	***0.679***	***1.389***	***1.631***	***5.111***	***-8.756***	***12.019***	***30.4***	***33.1***
Fd	GMR with intercept	36	34	1.451	0.175	1.096	1.806	-10.434	5.111	-20.822	-0.047	30.4	33.7
Fd	OLS no intercept	36	35	1.089	0.026	1.036	1.142	0.000				30.4	33.1
Fd	GMR no intercept	36	35	1.100	0.026	1.047	1.154	0.000				30.4	33.5
Fd	ROM	36	35	1.090	0.027	1.036	1.144	0.000				30.4	33.2
Fd	MOR	36	35	1.093				0.000				30.4	33.2
Fd	OLS no ratio	36	35	1.000	0.000			2.614	4.547	-6.616	11.845	30.4	33.0
Hw	OLS with intercept	58	56	0.694	0.173	0.348	1.041	9.803	4.617	0.554	19.053	25.7	27.7
Hw	GMR	58	56	1.468	0.173	1.122	1.814	-10.586	4.617	-19.835	-1.336	25.7	27.2
Hw	OLS no intercept	58	57	1.056	0.029	0.998	1.115	0.000				25.7	27.2
Hw	GMR no intercept	58	57	1.079	0.029	1.020	1.138	0.000				25.7	27.7
Hw	***ROM***	***58***	***57***	***1.066***	***0.030***	***1.007***	***1.126***	***0.000***				***25.7***	***27.4***
Hw	MOR	58	57	1.084				0.000				25.7	27.9
Hw	OLS no ratio	58	57	1.000	0.000			1.747	5.844	-9.956	13.450	25.7	27.5

[a]Degrees of Freedom
[b]Confidence Interval

Appendix E

Plot Volumes vs Managed Stand Yields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B_CWHvm2_01_gg0
J_CWHvm2_01_gg0
J_CWHxm_01_gg0
J_CWHxm_03_gg0
J_CWHxm_05_gg0
J_CWHxm_07_gg0
Q_CWHxm_01_gg0
9908
9909
9910
9924
9923
9951
9984
9932
9983
9930
9979
9946
9929
9907
Volume (m3/ha)
Stand Total Age (Years)
0
500
1000
1500
0
20
40
60

Appendix F

Years-To-Breast Height Calculations

TFL 47 Years to Breast Height Analysis

June 27, 2023

Methodology

The TFL 47 Years to Breast Height (Y2BH) analysis utilized the plot-based silviculture survey data collected in TFL 47. Data used in the TFL 47 Y2BH analysis was pulled out of the Land Resource Manager (LRM) using several queries (**Figure 2**), which were then combined in MS Access. Filters used to refine the initial data set are listed below in **Figure 1**.

Figure 1. Filters on initial data set for Y2BH analysis.

Licence	TFL47
Operation Code	JS (Johnstone Strait)
Survey Type	Regen Delay Plot, Regen Assessment Plot, Free Growing Plot
Survey Stratum Area	GIS area > 0 ha
Survey Status	D (Done)
Survey Start Date	>= 1/1/2010
Survey Layer	S (Silviculture Layer)
Survey Species	Cw, Fdc, Hw

The Regen Delay Plot and Free Growing Plot surveys are used to report silviculture milestone / obligation achievement and the associated Forest Cover is submitted to RESULTS. The Regen Assessment Plot surveys are conducted after the Regen Delay Plot and before the Free Growing Plot, as needed to monitor development of the regenerating stand. The Forest Cover associated with the Regen Assessment Plot survey is not typically submitted to RESULTS. Using the data from these three survey types resulted in a data set containing 3418 records, larger than RESULTS alone would provide.

Figure 2. Tree Height by Growing Season & Analysis Unit[1] (AU) Queries (MS Access).

01_Survey_AllHeights_Source_Filter	Filters Survey GIS Area > 0, Survey Species Height > 0
05_Survey_AU_AllHeights_GrowingSeason	Assembles data input survey heights, operating area TFL block lookup, and BEC Unit Site Series derived from the Eco Unit. The growing season of the particular Standard Unit (SU) survey is calculated, and area weighting is applied to the growing period[2].
06a_Survey_AllHeights_GrowingSeason_WeightedSum	Grouping by BEC Unit, Site Series, Species Code, growing season and sums the Survey GIS ha, growing period height weighted and obtains a count of surveys.
06b_Survey_AllHeights_GrowningSeason_Weighted_Average_By_AU	Calculates the growing period Height Area Weighted Mean.

The resulting table from the queries above was exported by species and combined in Microsoft Excel. The output spreadsheet is named *GrowingSeason_TreeHeight_WeightedAvg_AU_20230502.xlsx*. The output spreadsheet (20230502) graphs the number of growing seasons from the time of planting for Fdc and Cw (initial planting end date) and from the time of harvest completion for Hw (harvest end date). To find the total age of Fd and Cw at which breast height was achieved, add one year.

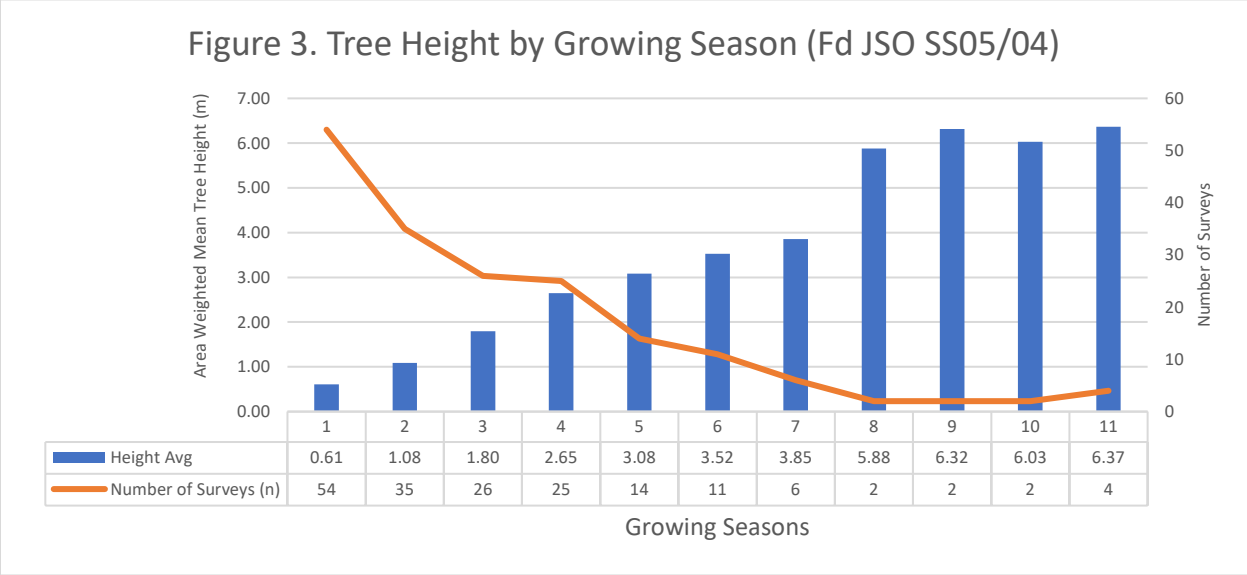
[1] Analysis Unit (AU) were broken up Biogeoclimatic subzones and Site Series groupings by TFL Block 17 (Bonanza), Block 12 (Quadra Island, including Chonat) and Blocks 2, 5-11 (JSO).

[2] A quality assurance review was completed on the results (i.e. removed records associated with NULL plant dates and species height = 0).

Results

Figure 3 illustrates the tree height by growing season for Fdc in the AU 'JSO CWH dm, xm, vm1, mm1 05/04'.

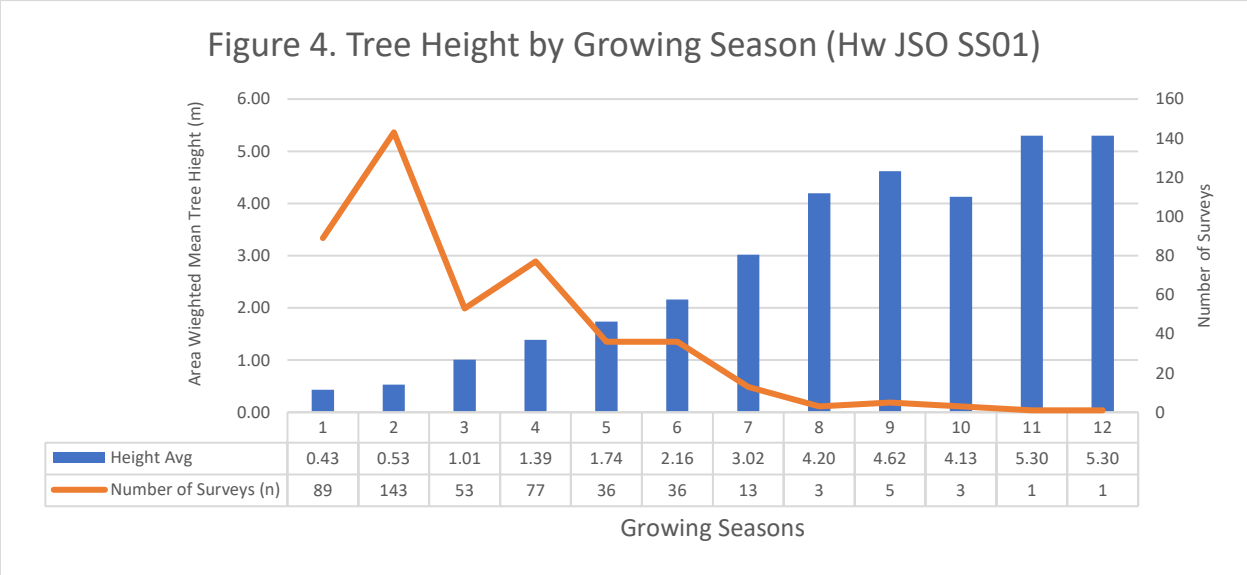
Using the example below, (1.80-1.08)/12 = 0.06 m growth per month. At this rate the 1.3 m height (breast height) is reached after 2 years and 4 months (2.3 growing seasons) or 3.3 years total age (one year added for 1+0 planting stock).



	1	2	3	4	5	6	7	8	9	10	11
Height Avg	0.61	1.08	1.80	2.65	3.08	3.52	3.85	5.88	6.32	6.03	6.37
Number of Surveys (n)	54	35	26	25	14	11	6	2	2	2	4

Figure 4 illustrates the tree height by growing season for Hw in the AU 'JSO CWH dm, xm, vm1, mm1 01'.

Using the example below, (1.39-1.01)/12 = 0.03 m growth per month. At this rate the 1.3 m height (breast height) is reached after 3 years and 9 months (3.8 growing seasons or total age (uses harvest end date for date of establishment).



	1	2	3	4	5	6	7	8	9	10	11	12
Height Avg	0.43	0.53	1.01	1.39	1.74	2.16	3.02	4.20	4.62	4.13	5.30	5.30
Number of Surveys (n)	89	143	53	77	36	36	13	3	5	3	1	1

Summary

The results of the Y2BH analysis, as illustrated in the output spreadsheet (20230502), results in the following Y2BH for Fdc, Cw and Hw, summarized by TFL Block and BEC / Site Series.

Table 1. Summary of Y2BH results for Fdc, Cw and Hw in TFL 47.

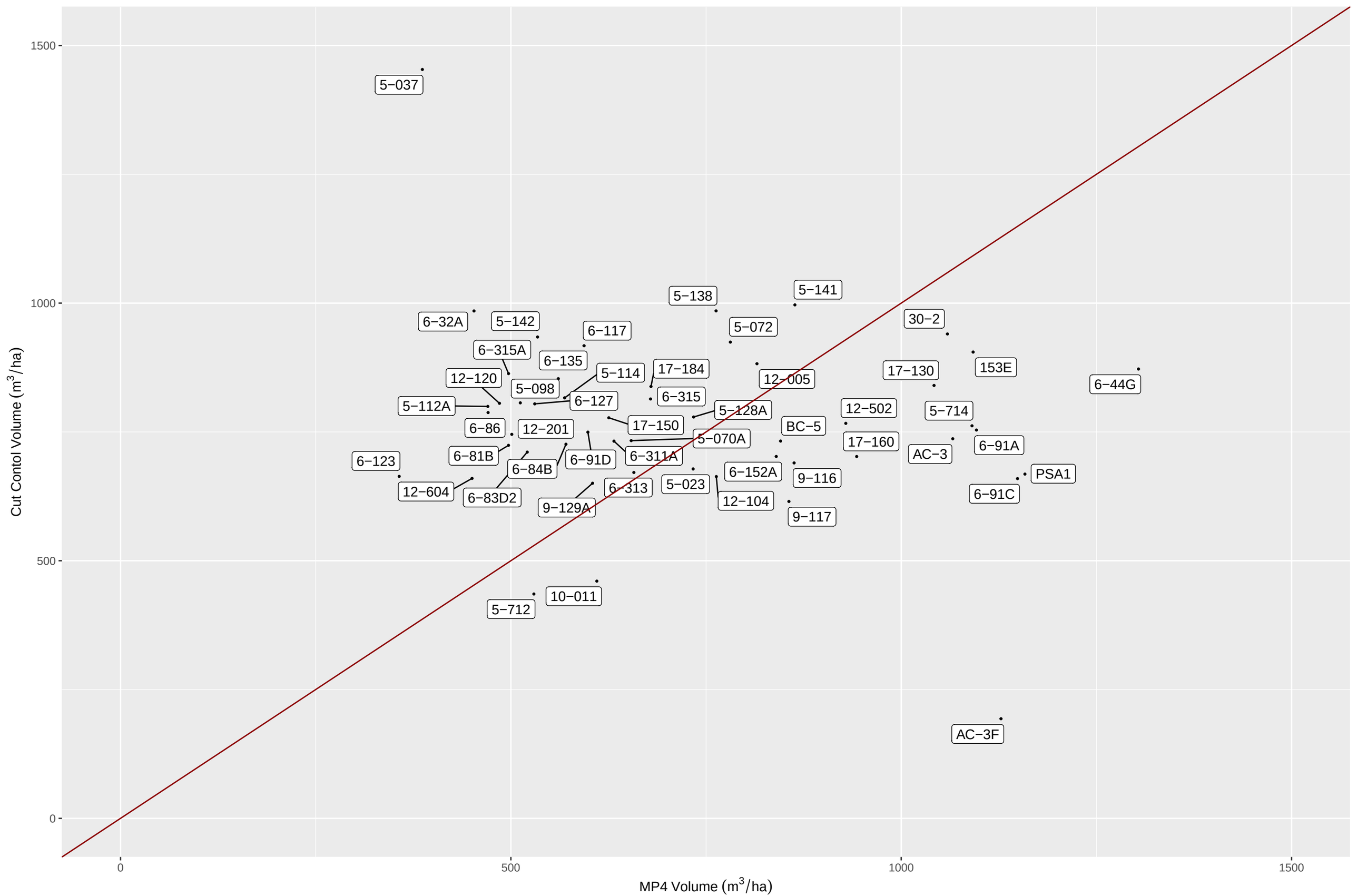
TFL Blocks	BEC / Site Series	Fdc (Y2BH)	Cw (Y2BH)	Hw (Y2BH)
Bonanza (Block 17)	CWH vm1 01			3.2
JSO (Blocks 2-11)	CWH dm, xm, vm1, mm1 01	3.5	4.3	3.8
JSO (Blocks 2-11)	CWH dm, xm, vm1, mm1 03/02	4.1		
JSO (Blocks 2-11)	CWH dm, xm, vm1, mm1 05/04	3.3	4.0	4.2
JSO (Blocks 2-11)	CWH dm, xm, vm1, mm1 06		4.5	4.5
JSO (Blocks 2-11)	CWH dm, xm, vm1, mm1 07/08	3.6	3.5	3.7
JSO (Blocks 2-11)	CWH vm2, mm2, MH mm1 All SS			6.1
Quadra (Block 12)	CWH dm, xm, vm1, mm1 01	4.3	4.8	3.5
Quadra (Block 12)	CWH dm, xm, vm1, mm1 05	3.8		
Quadra (Block 12)	CWH dm, xm, vm1, mm1 06		3.6	

Proposal

Based on the data collected in plot-based surveys conducted after January 1, 2010, TimberWest proposes to use the Y2BH results summarized in Table 1 to adjust the managed stand yield curves in the base case.

Appendix G

Natural Stand Yield vs Scaled Volume


Cut Contol Volume (m3/ha)
MP4 Volume (m3/ha)
0
500
1000
1500
5−037
5−138
5−141
6−32A
5−142
6−117
5−072
30−2
6−315A
6−135
5−114
17−184
12−005
17−130
153E
12−120
5−098
6−127
6−315
6−44G
5−112A
5−128A
12−502
5−714
6−86
12−201
17−150
BC−5
5−070A
17−160
6−91A
6−81B
6−91D
6−311A
AC−3
6−123
6−84B
6−152A
9−116
PSA1
12−604
6−83D2
6−313
5−023
12−104
6−91C
9−129A
9−117
10−011
5−712
AC−3F

Appendix H

Existing Road Classification

Background

Mosaic requested Ecora to prepare a work plan to assess overgrown trees on old roads and whether netdowns for old roads should be considered for the upcoming timber supply analysis. The purpose of this project is to compare stands on overgrown roads against surrounding stands to assess whether they are substantially different in terms of:

1) the characteristics of the trees (heights, species, dbh); and
2) density or crown closure.

Mosaic Forest Inventory

The forest inventory that Mosaic recently completed will be used for this analysis. That inventory was completed in two phases:

1) land base classification
2) forest inventory attribute estimation

Remote sensing data collected in 2021 was the basis for the inventory. That data consisted of:

1) Lidar data, Riegl VQ-1560i, with a minimum density of 12 pulses/m2, a maximum scan angle of 15 degrees on either side of nadir, 1+ ground points/m2, and an absolute accuracy of +/- 10cm RMSE. Over 280 ground truth control points have been collected throughout the project area by RTK and rapid static methods.
2) 4-band colour infrared aerial imagery with 20cm ground sample distance and 80% forward and 30% lateral overlap. This is at a scale of approximately 1:15,000.
3) Stereo Imagery from the above 4-band imagery was also produced.

Land Base Classification

Land base classification was the first step in the forest inventory process. The BCLCS was used as a starting point, but the system was modified early in the process to include only classes that could be distinguished using remote sensing data. These are the categories:

1) Anthropogenic
2) Treed
3) Clearcut
4) Lake
5) Rock/Rubble
6) Roads
7) Shrub
8) Snow/Ice
9) Stream
10) Transmission Line
11) Water (Wetlands)

Though ‘Roads’ are one of the land base categories identified, they are not classified based solely on remotely sensed data. The existing road network (spatial linework) was also one of the inputs. The road layer was reviewed manually over top of the digital imagery. The interpreter moved the line to the center of the visible road prism. Recently harvested

For Discussion

cutblock boundaries (those with regeneration less than 3m in height) were modified similarly and were also adjusted using a canopy-height model (CHM).

Using the adjusted road network, an indicator from the lidar processing (% ground returns) was used to assess the land base at a 2-m pixel scale. Pixels that were high in % ground returns were then aggregated into a polygon feature. A buffer of 10 meters from the centerline (determined through photo interpretation) was used to restrict road right of ways from running too far from the centerline in places where there is little observed height differentiation between the road and the surrounding land base (e.g., roads within new clearcuts, bordering or within swamps, etc.).

These road rasters are aggregated to polygons, e.g. microstands/nanostands (see below) representing the cleared road area.

Microstands and Nanostands

The first output dataset created by the classification process was a 2-metre raster. These rasters were then aggregated to produce microstand polygons. Microstands were subdivided to create nanostand polygons.

The microstands are intended to be small homogeneous stands, typically ranging from 0.2 hectares to 5 hectares in size, that reduce within-stand variation. The microstands are then further segmented into nanostands.

These nanostands do not cross microstand boundaries and are approximately the size of the inventory field plots that have been established. Nanostands are further aggregated along microstand boundaries to reduce the number of polygon slivers. Inventory attribute predictions were made at the nanostand level and then rolled-up to the microstand level. Further aggregation would be possible, depending on specific planning requirements.

Characterization of Over-Grown Roads

The land base classification process only picks up roads visible on imagery or distinguishable in the LiDAR data. The location of other older roads is recorded in Mosaic's GIS database. These roads can be buffered to a 10-metre total width and overlayed on the nanostand data.

From the images in Figure 1 below, we can see that areas that were previously considered roaded are indeed overgrown with tree cover. We developed a Canopy Height Model (CHM) with a 2-meter pixel resolution and 3-meter height threshold to remove these roads in the land cover classification process. This project intends to use nanostands, which are approximately 400 m^2 polygons, to evaluate the characteristics both on roads and adjacent to roads and report on the similarity between both areas. It is important to emphasize that the attributes calculated for each nanostand include any overgrown road area contained within it.

For Discussion

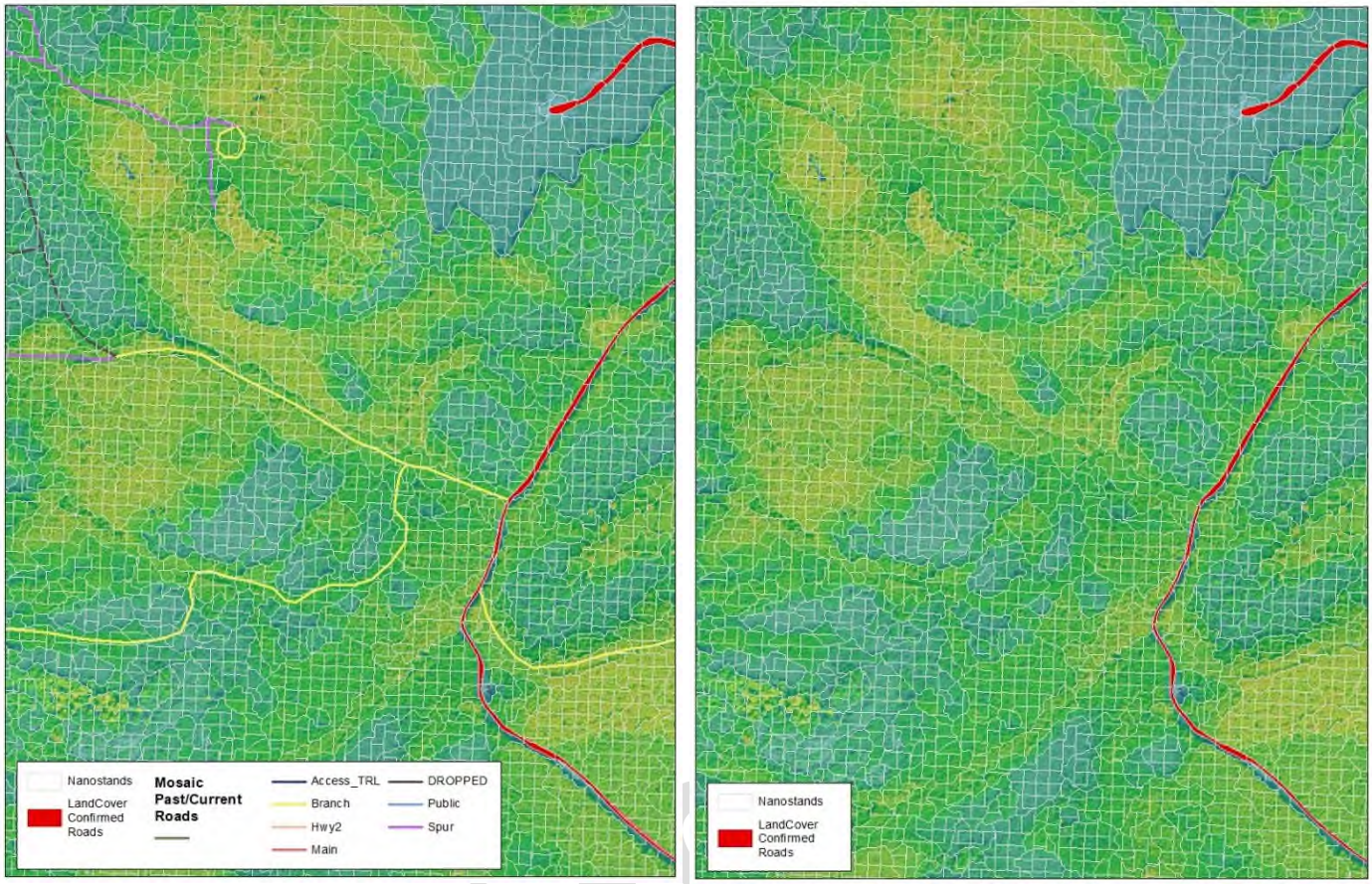


Figure 1. Example area with past and current roads (left) and roads removed where the Canopy Height Model height of trees is above 3m on the road surface, using a 2-m raster (right).

Methodology

1) Spatial Data Processing - Vector
    a) Align roads with imagery
    b) Buffer roads - 5 meters on each side
    c) Select nanostands that contain a road buffer
    d) Overlay (union) road buffers on selected nanostands
    - **Output: Vector dataset v1[unique_id, nanastand_id, road_t_f]**
2) Spatial Data Processing - Raster
    a) Calculate zonal statistics: v1 X chm (2-m raster)
    b) Calculate zonal statistics: v1 X canopy-gap (2-m raster)
    c) Calculate zonal statistics: v1 X slope (2-m raster)
    - **Output: R dataframe r1[unique_id, nanastand_id, road_t_f, ht, gap, slope]**
3) R Analysis
    a) height on-road vs not-on-road, by nanostand
    b) canopy gap % on-road vs not-road, by nanostand

c) classify each 2-m raster - road or not road

- **Output: R dataframe r2[nanostand_id, road_area_gis, road_area_classified]**

4) Point Cloud Review

a) review point cloud (cross sections) for a random sample of (100?) points on roads - across a range of slopes

b) classify as either 'road impact' or 'no road impact'

- **Output: point vector dataset v2[unique_id, nanastand_id, road_t_f, slope]**

5) Field Planning

a) select a subset of points for field visits

b) for each point, identify and map (3-5?) non-road points in the nanostand

c) prepare field packages for each point cluster

- **Output: Field Data Collection Packages**

6) Field Review

a) locate point clusters in the field

b) basal area sweep – record species

- **Output: Field Cards**

7) Data Compilation

a) compare height, density, canopy gap, and species composition for road and non-road areas

8) Report Writing

a) summarize methods, results

b) recommend a road netdown approach

- **Output: Final Report**

For Discussion